DOCUMENT RESUME

ED 306 139 SE 050 548

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TITLE Micros and Elementary Math: Lesson Plans, a Directory of Software for Achieving Educational Objectives and Procedures for Evaluating Software.
REPORT NO ISBN-0-918452-92-9
PUB DATE 86
NOTE 146p.; For a related document, see SE 050 549. Cover title varies slightly.
AVAILABLE FROM Learning Publications, Inc., 3008 Avenue C, Holmes Beach, FL 33509 ($19.95).
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052) -- Book/Product Reviews (072)

EDRS PRICE MF01/PC06 Plus Postage.
DESCRIPTORS Arithmetic; *Computer Assisted Instruction; Computer Software; *Computer Software Reviews; Computer Uses in Education; Elementary Education; *Elementary School Mathematics; Fractions; Geometry; Mathematical Concepts; Mathematics Education; *Mathematics Instruction; Mathematics Materials; *Microcomputers; Problem Solving

ABSTRACT

This book is organized in three major sections. The first section provides 15 lesson plans for the integration of activities involving computer uses in mathematics instruction. Each lesson plan includes grade level, objective, time, materials, important terms, background, suggestions, and activities. The second section provides a list of available math software covering addition; decimals; division; estimation; factoring; fractions; geometry; graphing; integers; money; multiplication; problem solving; rounding; and subtraction. Each software entry delineates the concepts to be taught, the appropriate grade levels, software titles and publishers, suggested retail costs, the types of computer hardware, and location of software evaluations. The third section describes human cognition and the evaluation questions for three categories of learning outcomes: verbal knowledge; intellectual skills; and cognitive strategies. Indices for software titles and publishers are included. Sample software evaluation forms are appended. (YP)

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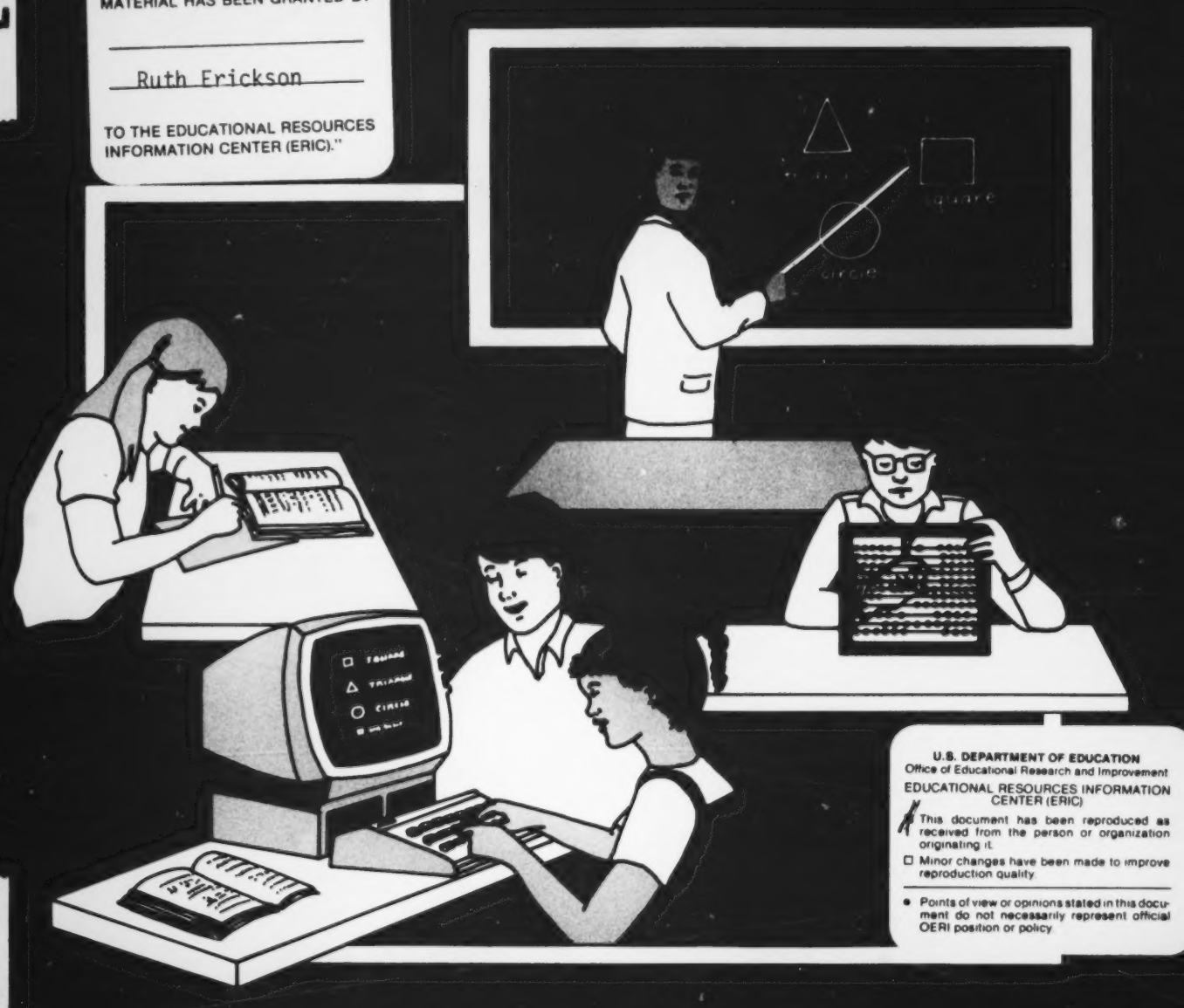

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MICROS AND ELEMENTARY MATH:

Lesson Plans, A Directory of Software For Achieving Educational Objectives and Procedures for Evaluating Software

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Learning Publications, Inc.
Holmes Beach, Florida

Library of Congress Number: 86-80555

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Learning Publications, Inc.
P.O. Box 1326
Holmes Beach, Florida 33509

Cover Design by Karen LeMonte

ISBN 0-918452-92-9

Printing: 1 2 3 4 5 6 Year: 6 7 8 9

Printed and bound in the United States of America

Preface

While the *Micros and Elementary Math* software directory includes a near complete listing of commercially available software for teaching math concepts, it is impossible to identify every piece of software. In future additions we will continue to add titles. If you are aware of any software that should be included in this directory, please send us your suggestions, preferably in the format used in the directory. Please mail your suggestions to:

Micros and Elementary Math
Learning Publications
P.O. Box 1326
Holmes Beach, FL 33509

We have also made a serious attempt to verify the validity and accuracy of each software listing, its appropriate concept and its hardware requirements. Of course, prices of software are subject to change and revision. We suggest that you check with the manufacturer or your distributor for current prices and availability. In addition, we make no representation or warranty regarding the contents hereof and specifically disclaim any implied warranties or merchantability or fitness for any particular purpose of any software or equipment. We also reserve the right to revise this publication and make periodic changes in the content hereof without obligation to notify any person or organization of such revision or changes.

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Tandy Corporation:	Radio Shack TRS-80 Models I-IV
Texas Instruments:	TI 99/4A

ACKNOWLEDGEMENTS

We would like to express our deepest gratitude to John B. Cooney for his valuable contribution to this project. John's insights into human information processing theory served as a catalyst for many sections of this project. We also acknowledge the editorial contributions of Learning Publications, Inc. Their staff served to provide significant help in the development of this book.

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Introduction

Micros and Elementary Math is organized around three major themes. The first theme is integrating microcomputer applications into math through model lesson plans based on learning outcomes. Second, is a directory of currently available software for the math teacher. And third, procedures for evaluating software.

Lesson plans provide for integrating activities involving computer use into math instruction. These lesson plans may be modified to meet individual teaching styles. Further, each lesson may be modified to be used with one computer or with several computers in a computer lab. For this reason lessons are not sequential. Each lesson plan includes a set of computer activities plus off-computer activities that may be used to reinforce desired skills and knowledge. Many topics can easily be adapted to full quarter or semester topics as well as daily or weekly lessons.

The software directory provides a list of available math software. However, this software directory is not intended to be an endorsement of any particular software. The software directory is generally organized around the same topics as the lesson plans. Included in the software directory are: the concept to be taught, the appropriate grade levels for the software, software title and publisher, suggested retail cost, the type of computer hardware necessary to run the software and where to locate software evaluations.

The probability of educational gains in each subject area should be the focus of software evaluations. Unfortunately, most educational software evaluations are preoccupied with computer related, presentational and often superficial features of the software. For example, an evaluator may focus on the appearance of graphics. Yet, teachers know that graphics, although they have eye appeal, may contribute little or nothing to desired student learning. Positive educational outcomes brought about by using the educational software is what is important. Using the evaluation criteria outlined in this book, teachers may increase the probability that any software they select will be appropriate for their teaching objectives.

PART A
LESSON PLANS

LESSON 1

ESTIMATION IN ADDITION

GRADE LEVEL: Grades 2 to 4

OBJECTIVE: When presented with any multiple digit addition problem, students will provide a reasonable estimate of the exact sum. Accuracy limitations depend on magnitude of factors and time allowed errors will not exceed 10%.

SUGGESTED INSTRUCTIONAL TIME: One 45 to 50 minute session.

IMPORTANT TERMS: Estimation, Sums

BACKGROUND: In an era of high technology estimation of arithmetic problems has become an extremely important skill for students to develop. As students use devices such as calculators and computers students often avoid the steps traditionally used to solve problems. By avoiding traditional steps students may be less likely to recognize if their answers "look" correct.

Calculation tools provide easy access to exact solutions and students take the results of these devices to be exact. However, solutions calculated on these tools are not always correct. A battery on a calculator could be low or an error could be made in pressing calculator keys. Whatever the reason, errors can occur. For these reasons recognition of unreasonable results is an important skill for all students who use these tools. It is important for all students to be able to recognize when an answer is probably wrong or when an answer is probably correct.

MATERIALS: Flash Cards or Computer, Chalkboard and Stopwatch

TEACHING SUGGESTIONS: On a chalkboard, display a three digit per factor addition problem. Review with students the traditional (right to left) procedure for solving a three digit addition problem. Separate the top and bottom components on the board to facilitate examination of each digit.

For example:

```
 378          3   7   8
+943        +   9   4   3
```

3

Look at each component separately. Explain to students that this three digit number is made up ones, tens and hundreds. Ask students to calculate component sums.

For example:

$$\begin{array}{rcrcrcr} 378 & = & 300 & + & 70 & + & 8 \\ \underline{943} & = & \underline{900} & + & \underline{40} & + & \underline{3} \\ 1200 & & 110 & & 11 & & \end{array}$$

Review the traditional method of addition and emphasize the difference between a left to right and a right to left procedure. Be sure students understand that estimation involves adding only one column at a time from left to right.

TRADITIONAL	ESTIMATION
378	378
+ 943	+ 943
1321	1200

On the chalkboard compare the solution with the sums of each individual column. For example, is 1321 closer to 1200, 110 or 11? Students should point out that 1200 is the closest number. Be sure students understand that adding the last column provides a closer estimate. Have students add the tens column to (120) to make the estimate a little closer. To get an exact sum add the ones column (11). Ask students to mentally calculate some multi-digit sums with each procedure. Let students discover that the estimation procedure is easier to do mentally.

Review and check student comprehension by providing a series of problems. Discuss situations where students might use each of the two procedures. For example, grocery shopping may involve an estimation procedure whereas counting school lunches needs to be exact.

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER:

On the chalkboard write a list of ten 2, 3 and 4 digit numbers. Beside each number place a letter. Tell students that you will select two numbers by calling out two letters. Students estimate the sum. Allow students only three seconds to provide an estimate. Be sure to check for accuracy. You may wish to do this activity in a game

format where the class is divided in to two groups and scores can be kept.

WITH A COMPUTER:

A simple computer program can be used to allow students to practice their skills at estimation. Before class type in and save the following program for students to use. If some students are familiar with entering computer programs, those students can be allowed to enter the program. Be sure you save the program for future use in your classroom. This computer program can be used by individuals or as a group activity. Students can take turns estimating a variety of problems.

```
100 REM     ESTIMATION PROGRAM
110 PRINT "Type in desired accuracy"
120 INPUT "(.05 OR .10)";PR
130 A = INT(RND(1)*899+100)
140 B = INT(RND(1)*999+10)
150 HOME:PRINT SPC(18);A
160 GOSUB 1000
170 PRINT B
180 PRINT:PRINT
190 INPUT "What is your estimate";EST
200 PRINT
210 IF EST > (A+B)+((A+B)*PR) THEN PRINT "Ooops - Too
     big":GOTO 190
220 IF EST < (A+B)-((A+B)*PR) THEN PRINT "Ooops
     Too small":GOTO 190
230 PRINT "Good Job - the actual sum = ";A+B
240 INPUT "PRESS RETURN TO CONTINUE";CNTU$:GOTO
     130
```

Note: The following sub-routine puts numbers in traditional vertical format. If you decide to eliminate the subroutine add a semicolon after A in 150 and replace line 160 with:

```
160 PRINT "   +   "
```

```
1000 REM   Format sub-routine
1010 VTAB 2
1020 J = LEN(STR$(B))
1030 FOR N = 1 TO 19-J:PRINT CHR$(32);:NEXT N
1040 PRINT "+ ";
1050 RETURN
```

The program listed above will work on a computer that uses APPLESOFT BASIC. If another form of BASIC is used, modify line 130 and 140. Consult the random number generation section of the appropriate manual.

REINFORCEMENT ACTIVITIES:

Whenever possible, students should include an estimate whenever they are doing addition problems. Worksheets should contain a blank for the estimate as well as the actual value. Remember, estimates should be limited to the first one or two left hand columns.

LESSON 2
MULTIPLICATION
CONCEPT DEVELOPMENT

GRADE LEVEL: Grades 2 to 4

OBJECTIVE: When presented with two single digit numbers, students will determine the product by counting the units in an array.

SUGGESTED INSTRUCTIONAL TIME: One 45 minute period.

IMPORTANT TERMS: Multiplication, Array

BACKGROUND: Developing an understanding of the concept of multiplication involves an understanding that multiplication is an extension of addition. Multiplication also involves an understanding of some new terminology. For example, in addition the term sum is used to represent the answer. In multiplication the term product is used to represent the answer. In addition, the symbol + is used. In multiplication the symbol X is used. Force of habit often causes problems for students when making the transition from addition to multiplication. Abundant practice distinguishing between different symbols and terminology is necessary to diminish these problems. In multiplication, visualizing the relationship between addition and multiplication helps students make the transition to the concept of multiplication.

MATERIALS: Chalkboard and Computer

TEACHING SUGGESTIONS: On the chalkboard write the following addition problem.

$$\begin{array}{r} 6 \\ +6 \\ \hline \end{array}$$

Ask students what the sum of the problem is. Point out that sum is the term used in addition to represent the answer. Also point out that the symbol + is used to indicate that the problem is an addition problem.

Next to the addition problem write the following multiplication problem.

$$\begin{array}{r} 6 \\ \times 2 \end{array}$$

Tell students that this problem is a multiplication problem. Ask students if they know why it is a multiplication problem. Students should notice the X in place of the + symbol. Also tell students that the word product is used to represent the answer for multiplication like sum is used to represent the answer in addition.

Explain to students that whenever they see a X symbol it means "groups of." In the above example, X2 means two groups of six. On the chalk board write several problems and ask students to identify the number of "groups of." For example,

$$\begin{array}{rrrrr} 5 & 2 & 7 & 2 & 5 \\ \times 2 & \times 5 & \times 3 & \times 8 & \times 1 \end{array}$$

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER:

Develop a worksheet that students can use to practice identifying the "groups of" in a series of problems. Provide several examples for students. In addition, provide a series of addition problems for students to identify. Students should practice until they can determine what type of problem and if there are "groups of."

WITH A COMPUTER:

To support the concept of "groups of" and to support the distinction between addition problems and multiplication problems the following BASIC program has been provided. Before class enter the program and save the program for future use. Students will be able to reuse the program anytime they are having difficulty distinguishing between addition and multiplication or identifying "groups of."

This program provides factors to be multiplied in two formats. The numeral for each factor is presented in addition to a table of asterisks. The total number of asterisks is equivalent to the product of the factors.

```
100 HOME: REM  MULTIPLICATION CONCEPT
      DEVELOPMENT
130 INPUT "ENTER A NUMBER BETWEEN 1 & 10  ";FX
140 INPUT "ENTER A SECOND NUMBER BETWEEN 1 &
      10  ";SX
```

```
150  PRINT:HTAB 11:VTAB 5
160  FOR P = 1 TO FX:PRINT P;"  ";
180  NEXT P:PRINT:PRINT
190  HTAB 9:PRINT "1  ";
200  FOR I = 1 TO FX:PRINT "*  ";
220  FOR T = 1 TO 500:NEXT T
230  NEXT I:PRINT:PRINT
240  IF SX < 2 THEN GOTO 340
250  FOR K = 2 TO SX
260  HTAB 9
270  PRINT K;"  ";
280  FOR L = 1 TO FX:PRINT "*  ";:NEXT L
310  PRINT:PRINT
320  FOR T = 1 TO 500:NEXT T
330  NEXT K
340  GOSUB 500
350  GOTO 100
500  REM  ANSWER PROCESSOR
510  PRINT:PRINT "COUNT THE STARS      "
520  PRINT FX;" X ";SX;" = ";:INPUT GUESS
530  PRINT:
540  IF GUESS <> FX * SX THEN PRINT "ASK YOUR
     TEACHER FOR SOME HELP ":GOTO 560
550  IF GUESS = FX * SX THEN PRINT "RIGHT ON "
560  PRINT: INPUT "PRESS RETURN TO TRY AGAIN ";CNTU$
570  RETURN
```

The program listed above will work on a computer that uses APPLESOFT BASIC. If any other form of BASIC is used consult the appropriate computer manual.

REINFORCEMENT ACTIVITIES:

Provide students with worksheets containing practical word problems involving simple multiplication problems. For students experiencing difficulty with the concept of multiplication, reemphasize counting by easy multiples (e.g., 2, 5 and 10). When students feel comfortable with these numbers ask students to count by less common multiples (e.g., 3, 7 and 9).

LESSON 3

PLACE VALUE

GRADE LEVEL: Grades 4 to 6

OBJECTIVE: When presented with numbers between six and six billion, expressed in words, students will provide the appropriate numeric expression.

SUGGESTED INSTRUCTIONAL TIME: Two 30 minute sessions.

IMPORTANT TERMS: Place Value

BACKGROUND: When students follow specific sets of instructions they can often calculate correct answers without necessarily understanding the concept. Number sense is achieved from the accumulated understanding of mathematic concepts. Unfortunately, when students learn how to solve problems without understanding the concepts involved, the ability to solve novel problems is decreased.

Place value is one concept which is an important prerequisite to efficient number sense. Place value is the concept where any digit takes on a different value simply by its location in a number. For example, in the number 346, six represents 6 ones. In the number 687, 6 represents 6 hundreds.

MATERIALS: Chalkboard and Computer

TEACHING SUGGESTIONS: Photocopy the place value concept sheet located at the end of this lesson. Cut along the dotted line and tape the right hand side to the top of the left hand side so that columns are aligned.

Talk students through the scheme step-by-step, spending the most time on the smaller numbers. Use "1"s during the introduction and substitute other digits as students begin to grasp the concept. Use the practice exercises to develop proficiency.

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER:

Provide students with worksheets which contain numbers expressed either numerically or in words. Have students fill in the numeric expression for the numbers expressed in text and words for the numeric expressions.

WITH A COMPUTER:

One application of a computer is to provide students with time to practice skills that have been developed in class. The following BASIC program is designed to let students practice the concept of place value. Before class spend a few minutes entering the following program. Be sure to save this program on a disk for future use and application. When saving this program be sure to name it PLACE.

```
100 HOME:RESTORE
120 PRINT SPC(10);"PLACE VALUE EXERCISE"
140 PRINT SPC(7);"MAKE SURE CAPS LOCK IS DOWN"
160 LET INC=0
180 LET SELECT = INT(RND(1)*9+1)
200 LET PRES = 6*10^9/(SELECT*10)
220 DATA SIX,SIXTY,SIX HUNDRED,SIX THOUSAND,
     SIXTY THOUSAND,SIX HUNDRED THOUSAND, SIX
     MILLION,SIXTY MILLION, SIX HUNDRED MILLION,
     SIX BILLION
240 FOR I = 1 TO SELECT
260 READ NUM$
280 NEXT I
300 PRINT
320  PRINT "USE THE PERIOD KEY TO MOVE THE
     CURSOR"
340 PRINT "PLACE A 'T' UNDER YOUR CHOICE":PRINT
360 PRINT "WHICH DIGIT REPRESENTS":PRINT
380 PRINT SPC(10);NUM$:PRINT
400 PRINT "   6 6 6 6 6 6 6 6 6 6"
420 INPUT CHOICE$
440 LET REF = SELECT + (29-(SELECT-1) * 4)
460 IF LEN(CHOICE$) <> REF THEN PRINT "SORRY THAT
     IS NOT RIGHT  TRY AGAIN":GOTO 420
480 PRINT "RIGHT ON, PRESS RETURN TO TRY AGAIN"
     :GET CNTU$
500 GOTO 100
```

Note: Spacing in line 400 is critical. Three spaces precede the first 6 with two spaces between the others.

The program listed above will work on a computer that uses APPLESOFT BASIC. If any other form of BASIC is used

consult the appropriate computer manual. The functions SPC, RND and LEN may need to be modified.

This program randomly generates a number containing a six in each place value location. A specific place value is then randomly selected. Students are required to select the digit representing that value. The program automatically checks student responses. Following are a set of simple instructions that students will need to correctly operate this program.

1. Ask students to type RUN PLACE to start the program.
2. When a number and a target place value appear, instruct students to press the "period" key until the cursor is under their choice.
3. To enter their choice, have students press the "T" key followed by return key.

REINFORCEMENT ACTIVITIES:

Understanding the concept of multiples of 10 is directly related to place value. Introduce students to equations involving multiples of 10. Have students complete worksheets with problems containing multiples of 10.

Place Value Worksheet

	10,000	:	1	
	10,000	:	1	
	10,000	:	1	
	10,000	:	1	
ten thousands	10,000	:	1	ones
	10,000	:	1	
	10,000	:	1	
	10,000	:	1	
	10,000	:	1	
	+10,000	:	+1	
	100,000	:	10	
	100,000	:	10	
	100,000	:	10	
one hundred	100,000	:	10	
thousands	100,000	:	10	tens
	100,000	:	10	
	100,000	:	10	
	100,000	:	10	
	100,000	:	10	
	+100,000	:	+10	
	1,000,000	:	100	
	1,000,000	:	100	
	1,000,000	:	100	
one million	1,000,000	:	100	
	1,000,000	:	100	hundreds
	1,000,000	:	100	
	1,000,000	:	100	
	1,000,000	:	100	
	1,000,000	:	100	
	+1,000,000	:	+100	
	10,000,000	:	1,000	
	10.000,000	:	1,000	
	10.000,000	:	1,000	
one hundred	10,000,000	:	1,000	
thousand	10,000,000	:	1,000	thousands
	10,000,000	:	1,000	
	10,000,000	:	1,000	
	10,000,000	:	1,000	
	10,000,000	:	1,000	
	+10,000,000	:	+1,000	
	11,111,111	:		
		:		

eleven million one hundred eleven thousand one hundred and eleven

LESSON 4
CARDINALITY

GRADE LEVEL: Grades K to 2

OBJECTIVE: When presented with a sequence of four adjacent numbers between one and twenty, students will correctly identify any numbers which have been omitted from the sequence.

SUGGESTED INSTRUCTIONAL TIME: One 30 minute session.

IMPORTANT TERMS: The counting words between one and twenty

BACKGROUND: A developmental model of the acquisition of cardinality emphasizes a step by step progression. Children must first learn the counting word sequence (one, two, three...). The ability to enumerate by making an association between the counting words and each member of a set leads to the determination of the number of items in the set. Realization that the last element counted represents the number of elements in the set satisfies the cardinality rule. Enumeration of the last member of the set as the answer to the question; How many are there? can lead to a correct answer but does not necessarily indicate cardinality. The concrete act of counting is far from the abstraction of a symbolic representation of a set. Instruction and experience can facilitate the development of cardinality.

MATERIALS: Chalkboard, Square of Cardboard and Computer

TEACHING SUGGESTIONS: On the chalkboard, write the numbers from 1 to 20. Leave 4-6 inches of space between the digits. Have students identify each number. Randomly select numbers and cover them with a piece of cardboard. Have students identify the missing number.

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER: Create a worksheet containing a series of four sequenced numbers with one of the numbers left out of the sequence For example,

5 ____7 8 2 3 ____5

Have students fill in the missing number.

WITH A COMPUTER:

As is the case with many activities that can be performed on a worksheet, a computer program can be written that will allow students to work individually or in groups to practice a variety of skills. The following BASIC program allows students to practice cardinality. Enter the program before class so students may use it for reinforcement once classroom instruction is complete. Be sure to save the program for future use.

```
100 HOME:INPUT "ENTER THE LARGEST NUMBER YOU
     WANT IN  THE SEQUENCE ";LIM
120 FOR REP = 1 TO 10
140 LET COUNT = 0
160 LET TERM = INT(RND(1)*LIM +1)
180 FOR I = TERM - 4 TO TERM
200 LET COUNT = COUNT + 1
220 LET SEQ(COUNT) = I
240 NEXT I
260 LET BLANK = INT(RND(1)* 4 + 1)
280 HOME:VTAB 6:HTAB 9
300 PRINT "WHAT NUMBER IS MISSING "
320 VTAB 8:HTAB 14
340 FOR J = 1 TO 4
360 IF J = BLANK THEN PRINT "___ ";:GOTO 400
380 PRINT SEQ(J);
400 PRINT SPC(2);:NEXT J
420 INPUT GUESS
440 PRINT:PRINT:PRINT SPC(12);
460 IF GUESS = SEQ(BLANK) THEN PRINT "YES  PRESS
     RETURN" :GOTO 500
480 PRINT "NO  TRY AGAIN":GOTO 420
500 GET CNTU$
520 NEXT REP
```

The program listed above will work on a computer that uses APPLESOFT BASIC. If any other form of BASIC is used consult the appropriate computer manual.

REINFORCEMENT ACTIVITIES:

Transition from concrete to abstract can be facilitated by removing individual elements from the visual field. Obtain a number of containers which are not transparent. Using a collection of identical small objects (e.g., marbles, beads, buttons, etc.) have students place a set number of objects in a container. Mark the container with a number that is equivalent to the number of objects in the container. This activity will help reinforce the cardinal number.

LESSON 5
ROUNDING DECIMALS

GRADE LEVEL: Grades 3 to 5

OBJECTIVE: When presented with a multiple digit decimal number, and instructions as to the desired place value, students will provide the number rounded to that place value. Accuracy will be 100%.

SUGGESTED INSTRUCTIONAL TIME: Two 30 minute sessions.

IMPORTANT TERMS: Significant Digits, Rounding

BACKGROUND: Few people enjoy arithmetic so much that they spend their leisure time doing long division. Working problems, which contain components that are smaller than that represented by the significant digits, is generally a waste of time. Recognition and proficiency at determining significant digits are important to the use of number sense. For example, rounding is a critical component of estimation. Adjustment to significant digits is accomplished with rounding.

MATERIALS: Chalkboard and Computer

TEACHING SUGGESTIONS: Discuss the meaning of the term "significant digits" with students. Be sure to point out to students that digit significance is relevant to the situation. For example, when measuring a log that will be cut with a chain saw, exact measurement to any decimal place is unnecessary. On the other hand, measurement of nerve cells in the human body requires use of many decimal places.

The most significant digit refers to the digit that contributes the largest amount to the total value of the entire number. For example, if the entire number is 47, then the 4 represents the largest contribution to the number. Proceed with an explanation of other significant digits. Once students understand the concept of significant digits, explain to students that the number to the right of the least significant digit is used in rounding. When the number to the right is 5 or above, then the significant digit is increased by 1.

In rounding, the numbers to the right of the significant digit are then changed to zeros (e.g., 47 is rounded to 50).

Be sure to provide students ample opportunity for rounding practice.

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER:

Have students complete a worksheet which requires students to round a variety of different numbers. Be sure to include the number 5 as the first number past the significant digit. In addition, be sure to vary the significant digit. For example, have students round to the nearest 10, 100, 10th and 100th.

WITH A COMPUTER:

The following BASIC program is designed to allow students to practice skills at rounding to various place values. This program will tell students if they have correctly rounded or not. In addition, this program will allow students to try again on any missed items.

```
100 D = INT(RND(1)*4+1)
110 HOME:VTAB 8:HTAB 8
120 NUM = RND(1)*10 ^ D
130 ROUND = INT(RND(1)*2+1)
140 PRINT "ROUND THE NUMBER ";NUM
160 PRINT:HTAB 8
180 PRINT "TO ";ROUND;" DECIMAL PLACES"
190 PRINT :HTAB 8
200 INPUT "ENTER YOUR GUESS ";GUESS
210 LET P = 10 ^ ROUND
220 PRINT:HTAB 8
230 LET ANSW = INT (NUM*P+.5)/P
240 LET ANSW$ = STR$(ANSW)
250 LET GUESS$ = STR$(GUESS)
260 IF GUESS$ <> ANSW$ THEN PRINT "INCORRECT
    TRY AGAIN":GOTO 190
270 PRINT :HTAB 8
280 PRINT "RIGHT ON PRESS RETURN"
300 GET CNTU$:GOTO 100
```

The program listed above will work on a computer that uses APPLESOFT BASIC. If any other form of BASIC is used consult the appropriate computer manual.

APPLESOFT BASIC. If any other form of BASIC is used consult the appropriate computer manual.

REINFORCEMENT ACTIVITIES:

Instruct students in estimation techniques and require that an estimated answer be given in addition to the calculated answer whenever an arithmetic problem is solved. Include variations in the decimal place which students should use as an estimate goal. For example,

$\overline{48/57.3692}$ estimate to the hundredths place.

LESSON 6

RELATIVE MAGNITUDE OF NUMBERS

GRADE LEVEL: Grades 1 to 5

OBJECTIVE: When presented with a number, students will be able to provide two single digit numbers that, when added or multiplied, will result in that sum or product.

SUGGESTED INSTRUCTIONAL TIME: One 45 minute period.

IMPORTANT TERMS: Sum or Product

BACKGROUND: Number sense is important in mathematics. An intuitive perception of the relative magnitude of numbers comprises an important aspect of number sense. Graphics which can vary in magnitude as factors change can provide a dynamic model for learning relative magnitude.

MATERIALS: Computer

TEACHING SUGGESTIONS: A goal of this lesson is the development of an intuitive understanding of the magnitude of numbers. To develop intuitive understanding, instruction beyond an introduction of the topic and directions is unnecessary. What is important is drill and practice.

SUGGESTED CLASSROOM ACTIVITIES: For this lesson you will have to enter the BASIC computer program provided before proceeding. Once the computer program has been entered and you are sure you have not made any mistakes, provide students with the following instruction.

Instructions:

To begin the game press the spacebar. A line will appear near the center of the screen and a number will appear near the bottom. That number represents the length of the line. The students task is to input two numbers which when _____ (added or multiplied) will equal the number at the bottom of the screen. Press return after entering each number. Notice the new line that appears when you enter a number.

```
100  REM RELATIVE MAGNITUDE
120  A = INT(RND(1)*9+1)
130  IF A <2 THEN GOTO 120
140  B = INT(RND(1)*9+1)
150  IF B <2 THEN GOTO 140
180  PRINT "TYPE 'SUM' FOR ADDITION"
200  PRINT "OR 'PROD' FOR MULTIPLICATION
     ":PRINT:INPUT OP$
210  HGR:HCOLOR=3
220  IF OP$ = "SUM" THEN GOSUB 500
240  IF OP$ = "PROD" THEN GOSUB 600
260  HPLOT 0,100 TO SUM*16,100
500  REM ADDITION SUBROUTINE
505  LET SUM = A+B:HPLOT 0,100 TO SUM*16,100
510  PRINT "ENTER TWO NUMBERS WHICH WHEN"
520  PRINT "ADDED = ";SUM:PRINT
530  INPUT "PRESS RETURN AFTER EACH NUMBER ";FX
540  HPLOT 0,125 TO FX*16,125
550  INPUT SX
560  HPLOT FX*16,130 TO (FX*16) + (SX*16),130
580  IF FX + SX <> SUM THEN GOTO 590
585  PRINT:INPUT "CORRECT, PRESS RETURN TO TRY
     ANOTHER ";CNTU$:GOTO 100
590  PRINT:INPUT "THAT IS NOT CORRECT, PRESS
     RETURN TO TRY AGAIN ";CNTU$:GOTO 210
599  RETURN
600  REM MULTIPLICATION SUBROUTINE
605  LET PROD = A*B:HPLOT 0,100 TO PROD*(3.55),100
610  PRINT "ENTER TWO NUMBERS WHICH WHEN"
620  PRINT "MULTIPLIED = ";PROD:PRINT
630  INPUT "PRESS RETURN AFTER EACH NUMBER ";FX
650  INPUT SX
660  HPLOT 0,125 TO (FX*SX*3.55),125
680  IF FX * SX <> PROD THEN GOTO 690
685  PRINT:INPUT "CORRECT, PRESS RETURN TO TRY
     ANOTHER ";CNTU$:GOTO 100
690  PRINT:INPUT "THAT IS NOT CORRECT, PRESS
     RETURN TO TRY AGAIN ";CNTU$: GOTO 210
699  RETURN
```

The program listed above will work on a computer that uses APPLESOFT BASIC. If any other form of BASIC is used consult the appropriate computer manual.

REINFORCEMENT ACTIVITIES:

Create a worksheet which contains addition or multiplication equations presented in pairs. Have the students indicate which equation would provide the largest answer. Do not require students to calculate an exact answer unless verification is needed.

LESSON 7
STELLAR TIME OF DAY
MENTAL ARITHMETIC

GRADE LEVEL: Grades 5 to 8

OBJECTIVE: When presented with a diagram depicting the relative locations of the North Star and the Big Dipper, students will state the actual time of day. Accuracy will be within plus or minus one hour of the actual time.

SUGGESTED INSTRUCTIONAL TIME: Two 45 to 50 minute sessions.

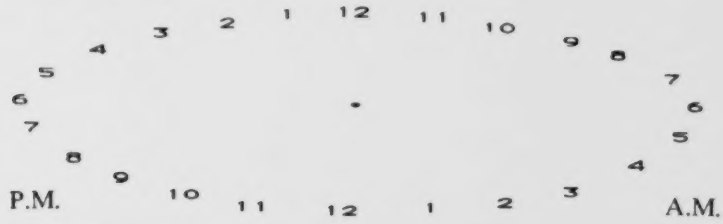
IMPORTANT TERMS: Estimation, Mental Arithmetic

BACKGROUND: Repetitive drill and practice of basic arithmetic facts and procedures are vital to mathematics proficiency. Student motivation to learn and comprehension of these facts can be facilitated by providing ample opportunity to use this knowledge in real life applications. This lesson provides a novel way of presenting an application problem which requires the use of mental arithmetic skills.

MATERIALS: Chalkboard, overhead projector or bulletin board. If a bulletin board is used, construct two sets of numbers from one to twelve and the Big Dipper. The Big Dipper should be constructed on transparent material.

TEACHING SUGGESTIONS: Either on the chalkboard or on a bulletin board, display a diagram of the constellations. Be sure that this diagram includes the North Star and the Big Dipper. Point out the Big Dipper. Be sure students note the two stars, the farthest right (F and G), on the Big Dipper. Notice that an imaginary straight line connecting these stars (extending away from the top) almost connects with a bright star, the North Star. The angle (crookedness) formed in connecting these three stars is always the same.

Draw a point in the middle of the chalkboard. Around this point, draw a 24-hour clock. Note: Only numbers one through twelve are used. Locations of the hours are depicted below.



Have students study and reproduce the clock face on a piece of paper. By laying the constellation over the clock diagram, students can imagine a line drawn, connecting the two right stars (F and G) of the Big Dipper and the North Star. This is the hour hand of a giant clock (See page 25). Point out to students that the hour hand of the clock is not accurate unless you do some mathematical calculations. In addition, ask students to write down and follow the directions below:

1. Multiply the current month by two (e.g., January = 1; February = 2; December = 12).

   (If the current month is March then students would calculate 3 X 2 = 6.)

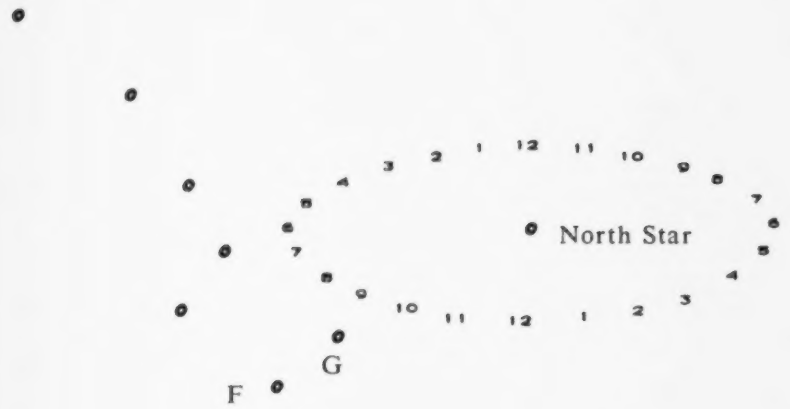
   Sample: If the current month is September, then calculate 9 X 2 = 18.

2. If the current day of the month is greater than or equal to 15 then add 1 to the result of rule #1 (e.g., If the day is September 18th, then add 1 to 18: 18 + 1 = 19).

   If the day of the month is less than 15, then do not add 1 to the day of the month.

3. If the result in rule #2 is greater than 24 then subtract 24 from the answer in rule #2 (e.g., 19 is not changed).

4. With the answer from step #2 or #3, count (e.g., 19) clockwise from stars F and G as noted on the Big Dipper. The number that you get is the actual time (e.g., If counting 19, you land on 5, or 5:00 P.M. If the count would have been to the 5 on the right side of the 24-hour clock, the time would be 5:00 A.M.).



SUGGESTED CLASSROOM ACTIVITIES:

Provide a series of diagrams of the Big Dipper and urge students to come up with the current time as quickly as possible. On the chalkboard, overhead projector or bulletin board simply move the Big Dipper from place to place as you change the date. Remember, the Big Dipper seems to be changing its location in the sky, but with a few calculations you can tell what time it is.

On a microcomputer you can have locations and dates chosen at random. The computer will output the answer to verify student guesses. A BASIC program is provided below that may be entered into the computer for students to use. You may want to have students enter the program for themselves to gain a better understanding of BASIC programming.

REINFORCEMENT ACTIVITIES:

Divide the class into two or three groups. Have groups compete on speed and accuracy of mental calculations of time using the date of star positions generated by the computer. Once a time is calculated by hand, have the groups verify their answer using the computer program.

This activity requires some estimation of the hour closest to the location of the Big Dipper. This is sometimes difficult for some students. It could prove to be a good opportunity to facilitate the realization that it is often beneficial to estimate.

BASIC PROGRAM

```
100 REM STELLAR TIME OF DAY
120 DIM X(24):DIM Y(24):DIM MTH$(12)
130 DIM TME$(24)
140 GOSUB 1000:GOSUB 2000
160 HGR:HCOLOR = 3
180 LOC=INT(RND(1)*23+1)
200 HPLOT 138,55
210 HPLOT X(LOC),Y(LOC)
```

```
220 GOSUB 3000:GOSUB 4000
240 INPUT "DO YOU WANT TO TRY AGAIN (Y OR
    N)";OPT$
260 IF OPT$="Y" THEN GOTO 160
300 END
1000 REM SUBROUTINE TO READ COORDINATES
1010 DATA 140,14,"12 AM",156,17,"11 AM",170,19,"10
    AM",184,26,"9 AM",194,35,"8 AM",202,45,"7 AM",205,55,"6
    AM",202,65,"5 AM",194,74,"4 AM",184,82,"3 AM",170,88,"2
    AM",156,94,"1 AM",140,95,"12 PM",122,94,"11
    PM",107,88,"10 PM",94,82,"9 PM"
1020 DATA 84,74,"8 PM",75,65,"7 PM",70,55,"6 PM",75,45,"5
    PM",84,35,"4 PM",94,26,"3 PM,107,19,"2 PM",122,17,"1
    PM"
1080 FOR TME = 1 TO 24
1100 READ X(TME),Y(TME),TME$(TME)
1140 NEXT TME
1300 RETURN
2000 REM DATE STRING SUBROUTINE
2020 DATA JAN, FEB, MARCH, APR, MAY, JUNE, JULY,
    AUG, SEPT, OCT, NOV, DEC
2040 FOR I = 1 TO 12
2060 READ MTH$(I)
2080 NEXT I
2100 RETURN
3000 REM RANDOMLY SELECT DATE
3020 M = INT(RND(1)*11+1)
3040 DAY = INT(RND(1)*29+1)
3060 PRINT "WHAT TIME WOULD THE STARS REPRESENT
    ON "
3080 PRINT SPEC(15);MTH$(M);" ";DAY
3100 RETURN
4000 REM CHECK ACTUAL TIME
4020 TMFAC = (M* 2) + 6
4040 IF DAY > 15 THEN TMFAC=TMFAC+1
4060 IF TMFAC>23 THEN TMFAC=TMFAC-24
4065 IF (24-LOC)>TMFAC THEN GOTO 4075
4070 ACTUAL=TMFAC-(24-LOC):GOTO 4080
4075 ACTUAL=LOC+TMFAC
4080 INPUT "ANSWER ";GUESS$
4090 IF LEN(GUESS$)>3 THEN GOTO 4100
4095 PRINT "YOU FORGOT SOMETHING":GOTO 4080
4100 IF VAL(LEFT$(GUESS$,1)) > VAL(LEFT$
    (TME$(ACTUAL),1))+1 THEN GOTO 4150
4120 IF VAL (LEFT$(GUESS$,1)) < VAL(LEFT$
    (TME$(ACTUAL),1))-1 THEN GOTO 4150
4140 PRINT "CORRECT":GOTO 4160
4150 PRINT "SORRY - THE CORRECT TIME IS
    ";TME$(ACTUAL)
4160 RETURN
```

LESSON 8

ESTIMATION IN MULTIPLICATION

GRADE LEVEL: Grades 3 to 5

OBJECTIVE: When presented with any multiple digit multiplication problem, students will quickly provide a reasonable estimate of the exact product. Accuracy limitations depend on magnitude of factors and time allowed. Errors, however, will not exceed 10%.

SUGGESTED INSTRUCTIONAL TIME: One 45 minute period.

IMPORTANT TERMS: Multiplication, Estimation

BACKGROUND: In this era of high technology the importance of arithmetic estimation skill has become prominent. Calculation tools are easily accessible for exact solution of problems. Recognition of unreasonable results is an important skill for users of these tools. For example, when the battery in a calculator becomes weak it will sometimes present incorrect results.

The ability to estimate is an important component of the "number sense" required for efficient mathematics ability. Mental arithmetic and estimation have been highlighted as important concepts which are presently underemphasized in the curriculum.

MATERIALS: Chalkboard and Computer.

TEACHING SUGGESTIONS: On the chalkboard, display a three digit per factor multiplication problem. For example,

```
 468
X32
```

Review the traditional (right to left) procedure.

Once students have reviewed the traditional process of solving multiplication problems, isolate the top and bottom components to opposite sides of the board. For example,

468 32

Break each digit into its component parts. Be sure students understand the place value of each digit. For example,

468 = 400 + 60 + 8 32 = 30 + 2

Be sure to review the concept of "most significant digits" to help students further their understanding of estimation in multiplication.

Identify the most significant digit in each factor. Point out that the most significant digits in the above equation are 4 and 3. Do not be overly concerned with student understanding of the concept at this point. If students are having difficulty understanding the concept of most significant digits, learning product estimation will facilitate comprehension of significant digits.

Review the concept of multiples of 10. Remind students that multiples of 10 are achieved by placing "0's" after the most significant digit. Have students extend the product of 4 and 3 to a product of 400 and 30. For example,

4 x 3 = 12 400 x 30 = 12000

Identify the second most significant digit in the first factor (6) and continue to use the most significant digit in the second factor (3). Have students identify the product of 6 and 3. Be sure students then extend the factors to their multiples of 60 x 30. For example,

6 x 3 = 18 60 x 30 = 1800

Identify the third most significant digit in the first factor (8) and continue to use the most significant digit in the second factor (3). Have students identify the product of 8 and 3 and extend to 8 x 30. For example,

8 x 3 = 24 8 x 30 = 240

Identify the one digit which still remains to be accounted for. The 2 in the second factor has yet to be used. Quickly repeat the sequence above using the second most significant digit of the second factor. For example,

400 x 2 = 800 60 x 2 = 120 8 x 2 = 16

On the chalkboard, add the sub-products obtained with each step.

12000 + 1800 + 240 + 800 + 120 + 16 = 14976

Compare this with the product obtained with the traditional long multiplication procedure.

```
  468
 x32
  936
 1404
14976
```

Discuss the differences between the two procedures. Point out that the left to right procedure often takes a longer amount of time to obtain the product. Have students imagine a situation where they have only a short amount of time to determine an answer. Compare the two procedures when only the first step is completed.

TRADITIONAL(left to right)	ESTIMATION (right to left)
1	
468	468 x 32
x32	
6	

Ask students to identify the procedure which yields an answer closest to the actual product. Point out that even though the estimation procedure requires a longer time to arrive at an exact product, a much closer approximation can be achieved in just a couple of steps.

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER:

Compile two separate lists, one with 2 and 3 digit numbers and another with 1 and 2 digit numbers. Label each number with a letter. Randomly select a number from each list by calling out two letters (one for each list). Have students estimate the sum within five seconds. Check for accuracy using long multiplication, a calculator or computer.

WITH A COMPUTER:

A computer can be used in direct mode to quickly solve arithmetic equations. To solve an equation in direct mode type: PRINT followed by the equation using a plus sign for addition, a slash for division and asterisk for multiplication. For example,

PRINT 468*32

REINFORCEMENT ACTIVITIES:

Have students derive and write a set of rules for estimating products. Whenever multiplication problems are presented to students, require that a reasonable estimate be made prior to calculation.

LESSON 9

FRACTIONAL PARTS

Fractions and Percentages

GRADE LEVEL: Grades 4 to 6

OBJECTIVE: When presented with a line and a percentage, expressed numerically, students will indicate the portion of the line that corresponds with that percentage. Accuracy will be within plus or minus 10 percent.

SUGGESTED INSTRUCTIONAL TIME: Ten minutes per student per session.

IMPORTANT TERMS: Percentage, Proportion

BACKGROUND: Visualizing a concrete representation of percentages or proportions are important to number sense. Exact procedures for calculation of problems using percentages can be accomplished without a "sense" of what is actually going on. It is important to provide students with ample opportunity to visualize abstract concepts such as percentage and proportion with a concrete representation.

MATERIALS: Computer and printer

TEACHING SUGGESTIONS: Two BASIC programs are provided below that are essential to the application of this lesson. Enter and save the first program. The first program is a visual aid for instruction on percentage and proportion. Use the second program to provide practice for students. The instructional program will print a series of numbers from one to one hundred on a number line.

Demonstrate the meaning of percentage by demonstrating the relationship between the numeric representation of a percentage and the equivalent position on the number line. Use common percentages first (e.g., 25%, 50% and 100%).
For example,

1. Have students examine a number line containing digits from 1 to 100.

2. Ask students to point to a number that represents the half way point in the number line (e.g., What percentage of a whole is equal to 1/2?).

3. Point out that the number 50 is halfway through the number line, indicating 50 percent.

4. Repeat steps 1 through 3 with 1/3, 1/4, 2/3 and 3/4.

5. Suggest to students that when dealing with percentages, they should imagine the quantity as being divided into 100 parts, as is the number line. Percentages are equivalent to that number of parts (e.g., 50 = 50% and 75 = 75%).

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER:

Create a work sheet with pictures of various objects and designated percentages. Have students indicate where the objects would be cut to be equivalent to the percentage. Have students use the example of the number line to help them solve each percentage problem.

WITH A COMPUTER:

The following instructional program can be used to create a number line that students may use in calculating percentages.

INSTRUCTIONAL PROGRAM:

```
100 PR#1
110 FOR I = 1 TO 100
120 PRINT "-";I
130 NEXT I
140 PR#0
150 END
```

Note: This program will work using Applesoft BASIC. With some other types you can eliminate lines 100 and 140 and substitute LPRINT for PRINT in line 120

Allow students to enter the following BASIC program. Once this program has been entered and students are sure it is correct, have students RUN the program to practice percentages.

STUDENT PRACTICE PROGRAM

```
100 REM PERCENTAGE
120 PCTGE = INT(RND(1)*100+1)
130 IF PCTGE < 10 THEN GOTO 120
140  PRINT "SOON YOU WILL SEE A LINE ON THE
     SCREEN."
160 PRINT "USING THE 'PERIOD' KEY, MOVE TO A POINT"
180 PRINT "WHICH YOU BELIEVE REPRESENTS ";PCTGE;"%"
200 PRINT "OF THE LINE SHOWN"
240 HGR:HCOLOR = 3
280 LET OLDLINE=(PCTGE/100)*240
290 HPLOT 0,130 TO 240,130
300 INPUT PERIODS$
310 LET NWLINE = LEN(PERIODS$)*7
320  IF NWLINE < OLDLINE-(OLDLINE*.1) THEN PRINT
     "TOO SHORT TRY AGAIN ";PCTGE; "%":GOTO 300
330  IF NWLINE > OLDLINE+(OLDLINE*.1) THEN PRINT
     "TOO LONG TRY AGAIN ";PCTGE;"%":GOTO 300
340 PRINT "GOOD JOB"
360 INPUT "PRESS RETURN TO CONTINUE ";CNTU$
380 GOTO 100
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used consult the appropriate computer manual.

REINFORCEMENT ACTIVITIES:

Use objects other than a line to provide students with practice in visualizing percentages. Review the lesson substitution percentages with fractions (e.g., 1/4, 1/2 and 1/1).

Practical examples may help students understand the concept of percentages. Locate some grocery products or advertisements which claim a percentage saving in cost. Have students estimate and then calculate the savings.

LESSON 10
DIVISION
CONCEPT DEVELOPMENT

GRADE LEVEL: Grades 2 to 4

OBJECTIVE: When presented with the product of two single digit numbers and one of the factors, students will determine the other factor by dividing the units in an array.

SUGGESTED INSTRUCTIONAL TIME: One 45 minute period.

IMPORTANT TERMS: Division, Array

BACKGROUND: An emphasis on arithmetic computation has resulted in too many students being able to solve division problems without understanding the concept of division. The development of understanding the concept of division involves the mental reversal of multiplication, plus some new terminology. Visualization of the relationship between division and multiplication facilitates an understanding of the concept. Regardless of the age and developmental level of students, when a new concept is learned the transition from concrete to abstract will have to occur. The following teaching suggestions review the concrete representation of multiplication and extend it to division.

MATERIALS: Chalkboard and Microcomputer

TEACHING SUGGESTIONS: On the chalkboard write the following multiplication problem.

$$\begin{array}{r} 6 \\ \times 2 \end{array}$$

Ask students to name the product of the problem. Remind students that product is the term used in multiplication to represent the answer. Also point out that the symbol X is used to indicate that the problem is a multiplication problem.

Next to the multiplication problem write the following division problem.

$2\overline{)6}$

Tell students that this problem is a division problem. Ask students if they know why it is a division problem. Students should notice the order of the problem is different and that the symbol is different. Tell students that division problems are read right to left rather than left to right. The problem above reads 6 divided by 2. Also tell students that the word "quotient" is used to represent the answer for division as "product" is used to represent the answer in multiplication.

Explain to students that, like multiplication, whenever they see a division symbol it means "groups of." In the above example, 2 means two groups of the quotient will equal six. On the chalkboard write several problems and ask students to identify the number of "groups of." For example,

$2\overline{)6}$ $3\overline{)9}$ $4\overline{)8}$

Provide examples that allow students to visualize grouping in division. Using a modified version of the program used in the multiplication lesson, print several examples and allow students to draw circles around the appropriate subgroups. When you are ready to let students practice:

a) change lines 130 and 140

b) delete line 145 (type 145 [return

c) change line 340 to gosub 600

d) replace the multiplication subroutine with the division routine. (600 - 670)

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER:

Develop a worksheet that students can use to practice identifying the "groups of" in a series of problems. Provide several examples for students. In addition, provide a series of addition and multiplication problems for students to identify. Students should practice until they can determine the type of problem and if there are "groups of."

WITH A COMPUTER:

To support the concept of "groups of" and to support the distinction between multiplication problems and division problems the following BASIC program has been provided. Before class enter the program and save the program for future use. Students will be able to reuse the program anytime they are having difficulty distinguishing between division and multiplication or identifying "groups of."

This program provides a table of asterics corresponding to the divided factors and the symbolic representation.

```
100  HOME: REM  DIVISION CONCEPT DEVELOPMENT
130  LET FX = INT(RND(1)*9+1)
140  LET SX = INT(RND(1)*9+1)
150  PRINT:HTAB 11:VTAB 5
160  FOR P = 1 TO FX:PRINT P;"  ";
180  NEXT P:PRINT:PRINT
190  HTAB 9:PRINT "1  ";
200  FOR I = 1 TO FX:PRINT "*  ";
220  FOR T = 1 TO 500:NEXT T
230  NEXT I:PRINT:PRINT
240  IF SX < 2 THEN GOTO 340
250  FOR K = 2 TO SX
260  HTAB 9
270  PRINT K;"  ";
280  FOR L = 1 TO FX:PRINT "*  ";:NEXT L
310  PRINT:PRINT
320  FOR T = 1 TO 500:NEXT T
330  NEXT K
340  GOSUB 600
345  HOME
350  GOTO 130
600  REM ANSWER PROCESSOR
610  PRINT "WHAT IS ";SX*FX;" DIVIDED BY ";FX
620  PRINT "HINT - COUNT THE GROUPS OF ";FX
630  INPUT "HOW MANY GROUPS ";GUESS
640  IF GUESS <> SX THEN PRINT "ASK YOUR TEACHER
       FOR SOME HELP":GOTO 660
650  PRINT "RIGHT ON"
660  INPUT "PRESS RETURN TO TRY AGAIN ";CNTU$
670  RETURN
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used consult the appropriate computer manual. Consult the technical manual accompanying your version of BASIC if you are not using Applesoft BASIC. If the Randomize function is not appropriate remove the REM from 110 and 120. Check the appropriate syntax for line 120.

REINFORCEMENT ACTIVITIES:

Provide students with worksheets containing practical word problems involving simple division problems.

LESSON 11
AVERAGE

GRADE LEVEL: Grades 5 to 6

OBJECTIVE: When presented with a list of numbers, students will state a number representing the average value. The stated average will be within plus or minus 10% of the actual average.

SUGGESTED INSTRUCTIONAL TIME: One 45 minute period

IMPORTANT TERMS: Average, mean, range

BACKGROUND: The concept of average is often difficult for an elementary school student. A source of confusion arises when a number is identified which is sometimes a member of the original set and sometimes is not. The abstract notion that one number can represent a set of numbers is critical to understanding the concept of numeric average or mean. Often the concept of average is equated to the formula for computing the average (i.e. Question: What does average mean? Answer: The total divided by the number of elements).

MATERIALS: Chalkboard and Microcomputer

TEACHING SUGGESTIONS: Choose a characteristic of your class that can be represented with integers (e.g., years of age, locker numbers, weight, etc.). List a sample of 10 ages on the chalkboard in decreasing or increasing order. Ask students to identify the one that is the closest to the middle of the range.

Calculate the average age and compare it to the number identified as the closest to the middle by students. Discuss the difference with students. Ask students why there was a difference (i.e., the numeric average is an exact midpoint while the other is an estimate).

Introduce the concept of range as the magnitude from the smallest number to the largest number. Determine the number of elements in the set.

10 12 11 10 11 10 9 13 10 9

Ask students to picture how it is possible to divide the range into equal increments. Start with two and continue until it is divided into a number of increments equal to the number of elements in the set.

9_____13

Convert the range into the sum of the elements in the list by unitizing each number.

10 12 11 10 11 10 9 13 10 9

1111111111,11111111111,1111111111,...

Have students divide the sequence of 1s into as many equal groups as there were elements in the original set.

Have students develop a rule for calculating averages.
(i.e. The sum of the elements divided by the number of elements).

Have students practice estimating and calculating averages.

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER:

Provide a worksheet with lists of values to be averaged. Be sure to use as many units of measure as possible. For example, have students average age of family, weight and the number of members in classes at school.

WITH A COMPUTER:

The following program allows students to estimate an average at a variety of difficulty levels. The output includes a series of digits to be averaged, an indication of whether each value is too large to be averaged, and an indication of whether each value is too small to be averaged. This program allows students to enter the correct answer or a close enough answer, if it is within 10%.

```
100  FOR I = 1 TO 10:REM AVERAGE
110  HOME
120  INPUT "SELECT AN UPPER LIMIT ON NUMBER SIZE
      10, 100 OR 1000 ";SIZE
130  HOME
140  LET RANGE = INT(RND(1)*6+3)
150  LET TTL = 0
160  FOR I = 1 TO RANGE
170  LET DIGIT = INT(RND(1)*SIZE)
180  PRINT SPC(1);DIGIT;
190  LET TTL = TTL + DIGIT
200  NEXT I
210  LET AVE = INT(TTL/RANGE+.5)
220  PRINT:PRINT:PRINT "GUESS THE AVERAGE "
230 INPUT "ROUNDED TO THE NEAREST WHOLE NUMBER
      ";GUESS
240   IF GUESS > AVE+(AVE*.1) THEN PRINT "TOO LIG
      TRY AGAIN ":GOTO 220
250  IF GUESS < AVE-(AVE*.1) THEN PRINT "TOO SMALL
      TRY AGAIN ":GOTO 220
260  PRINT "CLOSE ENOUGH - THE EXACT AVERAGE =
      ";AVE
270  NEXT I
280  END
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used consult the appropriate computer manual.

REINFORCEMENT ACTIVITIES:

A program to compute averages is fairly simple. If you have students who know or are learning to program in BASIC let them write the program from scratch. This will not only help them learn programming but will reinforce an understanding of numeric average as well.

LESSON 12

MULTIPLES OF 10

GRADE LEVEL: Grades 3 to 5

OBJECTIVE: When presented with a multiple digit number, multiplied or divided by a multiple of 10, students will determine the answer without using long division or multiplication. Accuracy will be 100%.

SUGGESTED INSTRUCTIONAL TIME: One 45 minute period.

IMPORTANT TERMS: Multiples of 10, decimal place

BACKGROUND: Power in mathematics skill involves efficiency as well as concept understanding. A concept involved with efficiency is the notion of multiples of 10. This concept is a critical pillar in the foundation of exponents, scientific notation, estimation and mental arithmetic. A clue indicating a deficiency in number sense is obvious when observing a student do long division or multiplication when one of the factors is a multiple of 10. For example,

```
  400
10/4000
 40
  0
  0
   0
   0
```

MATERIALS: Chalkboard or overhead projector and computer

TEACHING SUGGESTIONS: On a chalkboard or overhead projector, display a series of multiplication problems with a common multiple digit as the first factor and 10, 100 and 1000 as the second factor. Be sure to include decimal points and answers. For example,

7349	7349	73.49
x 10	x100	x 1000
73490	734900	73490.00

Ask students to find a pattern in the above examples. Be sure to highlight the common 7349 in each answer.

On the chalkboard or overhead display three division problems with the same factors. For example,

$$\frac{734.9}{10/7349.} \qquad \frac{73.49}{100/7349.} \qquad \frac{7.349}{1000/7349.}$$

Again, ask students to look for a pattern.

Have students define multiples of 10. Once students have defined multiples of ten, have students come up with a rule for multiplying and dividing by a multiple of ten.

Once students have come up with a rule provide students with an opportunity to practice and verify their rule.

SUGGESTED CLASSROOM ACTIVITIES:

WITHOUT A COMPUTER:

Create a worksheet for students with multiplication and division problems containing multiples of 10.

WITH A COMPUTER:

The following computer program is designed to allow students ample opportunity to practice their skills at using multiples. Allow students time to work individually or in small groups to help students become familiar with the concept of multiples.

```
100 REM MULTIPLES OF 10
110 HOME
120 LET X=INT(RND(1)*9+1)
130 PRINT "CHOOSE MULTIPLICATION OR DIVISION"
140 INPUT "BY PRESSING '*' OR '/' THEN 'RETURN'";OP$
150 PRINT "CHOOSE A MULTIPLE OF 10"
160 INPUT "BY TYPING IN THE NUMBER 10, 100, 1000
    ";MUL
170 IF OP$ = "*" THEN ANSW=X*MUL
180 IF OP$ = "/" THEN ANSW=X/MUL
190 PRINT:PRINT "ENTER THE PRODUCT OR QUOTIENT
    OF "
195 PRINT MUL;" AND ";X;" ";:INPUT GUESS
200 IF GUESS <> ANSW THEN PRINT "SORRY TRY AGAIN "
    :GOTO 190
210 PRINT "GOOD JOB"
220 INPUT "PRESS RETURN TO TRY AGAIN ";CNTU$
230 GOTO 110
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used consult the appropriate computer manual.

REINFORCEMENT ACTIVITIES:

Review the lesson using larger multiples of ten by changing the value in line 120 from 9 to 99 or 999. The higher the value in line 120 the larger the number generated by this program.

LESSON 13
ABSOLUTE VALUE

GRADE LEVEL: Grades 5 to 6

OBJECTIVE: Given any two negative or positive numbers, students will state the absolute value of each with 100% accuracy.

SUGGESTED INSTRUCTIONAL TIME: One 45 minute period.

IMPORTANT TERMS: Absolute value

BACKGROUND: Absolute value is an abstract concept which has frequent practical application. For example, the drop in temperature from above zero to below zero involves the addition of absolute values. The concept will be easily mastered by some students while being very difficult for others. The following provides an exercise which allows concrete visualization of the abstract concept of absolute value.

MATERIALS: Chalkboard and computer.

TEACHING SUGGESTIONS: As with any new concept there are new terminology and new symbols. Explain to students that absolute value is any positive or negative number without regard to it's positive or negative. For example, the absolute value of -3 is 3. The absolute value of +3 is 3. Explain to students that absolute value is represented by the number surrounded by lines. For example,

Absolute value of -3 |3|

On the chalkboard put a series of positive and negative integers. Have students state the absolute value of each number.

SUGGESTED CLASSROOM ACTIVITIES:

WITH A COMPUTER: Have students create, using a microcomputer and printer, two number lines. For example,

line number 1: increments from 1 to 20
line number 2: increments from -9 to +9

The -9 to +9 number line will provide a frame of reference for numbers on both sides of zero (0). The number line from 0 to 20 provides a means of visualizing the absolute value of any number. For example,

Select an integer value between -9 and +9. Place the 0 to 20 number line alongside the -9 to +9 number line so that 0 of both lines are together.

The following BASIC program will create the number lines that students can use for this lesson.

```
100 REM PROGRAM TO PRINT 1 TO 20 LINE
110 PR#1:REM SELECT PRINTER
120 FOR I = 0 TO 9
130 PRINT I;"  -"
140 NEXT I
150 FOR I = 10 TO 20
160 PRINT I;" -"
170 NEXT I
180 PR#0: INPUT "ADJUST PRINTER TO NEXT PAGE, THEN
      PRESS RETURN ";CNTU$:PR#1
200 REM PROGRAM TO PRINT -9 TO +9
220 FOR I = 9 TO 1 STEP -1
230 PRINT I*-1;" -"
240 NEXT I
250 FOR I = 0 TO 9
260 PRINT "+";I;" -"
270 NEXT I
280 END
```

The program listed above will work on a computer that uses Applesoft BASIC. If any other form of BASIC is used consult the appropriate computer manual.

REINFORCEMENT ACTIVITIES:

Provide students with a series of two locations on the -9 to +9 number line and have them determine the sum using the 1 to 20 line.

After students have demonstrated proficiency with determining sums of absolute values, generalize the concept to practical situations. For example:

1. The weather announcer reports that the temperature dropped from 13 degrees above zero to 17 degrees below zero. What was the temperature drop?

2. On your vacation you travel from Estes Park, Colorado (7000 feet above sea level) to Death Valley, California (200 feet below sea level). What was your total altitude change during your trip?

LESSON 14

DEVELOPING CONVERSION FACTORS IN MEASUREMENT

GRADE LEVEL: Grades 5 to 6

OBJECTIVE: When presented with a table of comparisons between measurement units, students will accurately calculate the appropriate conversion factor for any adjacent pair of units.

SUGGESTED INSTRUCTIONAL TIME: Two 45 minute periods.

IMPORTANT TERMS: Measurement, Conversion factors, Volume, Length, Weight

BACKGROUND: The ability to transform measurements from one unit to another (e.g. yards to feet, cups to quarts) has many practical applications. A variety of methods can be used to solve problems involving measurement units at different levels. Levels in this context represent the various magnitudes within one category (e.g., volume units of pint, quart, liter, milliliter, etc. or length units of meter, foot, yard, centimeter, etc.). Use of a ratio (e.g., 24 cups/x = 4 cups/1 quart) and cross multiplication (e.g., 4x =23 x=23/4 x=6 quarts) is a common way of dealing with such a problem. An equivalent but different way of looking at this procedure yields a more appropriate procedure for a modern curriculum. The prevalence of computer technology in education and industry has changed the educational needs of students. Cross multiplication of a ratio is a procedure designed for manual calculation and is not directly applicable in a computer program. Determination of a conversion factor for any pair of units (within a common category) would be a more straight forward approach for someone who is computer literate. The following lesson plan outlines the development of measurement conversion factors.

MATERIALS: Chalkboard and microcomputer or calculator, meter stick and one foot ruler.

TEACHING SUGGESTIONS: Following is a list of instructions for teaching students conversion factors. At each step, be sure students understand each concept. If students are having difficulty be sure to repeat the step until all students are ready to proceed.

1. On the chalkboard, display the following table of unit comparisons.

LENGTH	VOLUME
1 foot = 12 inches	1 pint = 2 cups
1 yard = 3 feet	1 quart = 2 pints
1 mile = 1760 yards	1 gallon = 4 quarts

2. Ask students questions concerning the table to assess comprehension (review if necessary). Pick one pair for use as an example (1 yard = 3 feet). Using a one foot ruler and a meter stick discuss the relative lengths.

3. Explain to students how to express the relationship as a fraction, with the unit desired as the denominator. For example,

convert to yard	convert to feet
3 feet / 1 yard	1 yard / 3 feet

4. Explain to students that this fraction can be converted to a decimal. For example,

convert to yard	convert to feet
3/1 = 3.00 = 300%	1/3 = .33 = 33%

5. Tell students how to restate the relationship using percentage terminology. For example,

convert to yard	convert to feet
1 foot = 33% of 1 yard	1 yard = 300% of 1 foot

6. Once students understand the relationship of measurement in percentage terminology tell students how to define a measurement unit conversion factor. For example,

   A conversion factor is the relationship between units expressed in decimal form. Provide students with an example that uses the conversion factor in the following equation.

   unknown units = conversion factor * known units

7. Have students use the conversion factor in an example problem.

   An olympic size swimming pool is 150 feet long.
   How many yards long is an olympic size pool?

   Question: Which conversion factor is appropriate?
   Answer: feet to yards

   Question: What is the conversion factor?
   Answer: .33

8. Explain to students the conversion rule. Be sure students understand each of the missing variables.

   unknown unit = factor * known
   ___ yards = .33 * feet
   ___ yards = .33 * 150
   50 yards

   Calculations can be done by hand or with a microcomputer/ calculator. With a microcomputer use the direct mode. To use direct mode simply type PRINT followed by the equation. For example,

   PRINT .33*150

   This will result in an answer expressed in a greater number of digits than practical.

9. Repeat steps 3 - 8 with other pairs of measurement units.

SUGGESTED CLASSROOM ACTIVITIES:

Have students construct a table of conversion factors (rounded to two decimal places) for the basic units of length, weight, and volume. It is recommended that students find the unit comparisons in an encyclopedia or dictionary rather than being provided by the teacher.

REINFORCEMENT ACTIVITIES:

Provide students with a list of practical application problems requiring the conversion of measurement units.

Repeat the lesson using unit conversions across metric and US standards (e.g. yards to meters).

LESSON 15

USE OF CONVERSION FACTORS IN MEASUREMENT

GRADE LEVEL: Grades 4 and 5

OBJECTIVE: When presented with an original value, an original unit, an alternative unit and a table of conversion factors, students will correctly convert the original value to the appropriate alternate value.

SUGGESTED INSTRUCTIONAL TIME: Two 45 minute periods

IMPORTANT TERMS: Conversion factor, volume, length and weight

MATERIALS: Chalkboard and microcomputer

BACKGROUND: The ability to transform measurements from one unit to another (e.g. feet to yards, cups to quarts) has many practical applications. Some unit conversions are encountered with enough frequency that the conversion will become relatively automatic. For example, 10 yards = 30 feet. Other transformations often require us to "look up" a factor which defines the relationship between units. Computers and calculators can be used to complete the transformation without displaying the arithmetic. For example, a computer program may state:

"Enter a specified number of feet"

"Press the key representing the correct number of yards"

While this is quite functional it is not particularly useful for teaching the underlying concepts. The program included with this lesson plan requires students to enter an original value and the appropriate conversion factor. The computer then prints the equation used to calculate the converted value. Students should be familiar with basic measurement concepts and units before proceeding with this lesson.

TEACHING SUGGESTIONS: Review the general topic of measurement. Students should understand the relationship between several different units of measurement. If students are having difficulty have students review the conversion process described in Lesson 14.

Review with students the use of conversion factors to solve word problems involving measurement. For example,

A recipe for punch calls for 3 and 1/2 pints of carbonated water. You only have a 1 cup measuring container. How many cups of carbonated water would you use?

Have students identify the problem parameters in the above story problem. For example,

conversion direction:	pints to cups
conversion factor:	2 cups/1 pint = 2.00
conversion equation:	cups (unknown) = 2.00 * 3 1/2 pints

Answer: 7 cups

Provide a series of measurement conversion word problems. Use a calculator or microcomputer to solve conversion equations.

SUGGESTED CLASSROOM ACTIVITIES:

WITH A CALCULATOR:

Have students use a calculator to solve conversion equations. Students should write the equation on paper before entering it into the calculator. A review of significant digits and rounding may be necessary since the calculator output will be expressed in many digits.

WITH A COMPUTER:

Type (or have students type) the following BASIC program into a microcomputer. Once this program has been successfully entered into the computer allow students ample time to work individually or in groups to practice several conversions.

```
100 INPUT "ENTER THE ORIGINAL UNIT ";KNO$:PRINT
120 PRINT "HOW MANY ";KNO$;:INPUT KNO:PRINT
130 INPUT "ENTER THE DESIRED UNITS ";UNK$:PRINT
140 PRINT "ENTER THE CONVERSION FACTOR FOR ";
160 PRINT: PRINT KNO$;" TO ";UNK$;
180 INPUT FAC
200 LET NW = INT(KNO*FAC+.5)
220 PRINT "___";" ";UNK$;" = ";KNO;" * ";FAC
240 PRINT
260 PRINT NW;" "UNK$
```

REINFORCEMENT ACTIVITIES:

Have students practice creative problem solving by experimenting with different ways of converting measurement units. Students should be encouraged to develop their own strategies for converting several different measurements.

PART B
MATH SOFTWARE DIRECTORY

CONCEPT: Addition
LEVEL: Grades 3 to 6
SOFTWARE TITLE: Circus Math
PUBLISHER: MECC Distribution Center
3489 Lexington Avenue North
St. Paul, MN 55112
SUGGESTED PRICE: $43.00
HARDWARE: Apple II
DESCRIPTION: Circus Math is a drill and practice package consisting of five programs which are presented to students upon mastery of the previous program's objectives. The first program begins with single digit whole numbers and the programs progress to three, two-digit addends, without regrouping. A teacher - management option is included.
EVALUATION: *Arithmetic Teacher*, January, 1986.

CONCEPT: Addition
LEVEL: Grade 3
SOFTWARE TITLE: Addition Logician
PUBLISHER: MECC Distribution Center
3489 Lexington Avenue North
St. Paul, MN 55112
SUGGESTED PRICE: $43.00
HARDWARE: Apple II
DESCRIPTION: Addition Logician is a drill and practice package consisting of five programs that vary in difficulty. Addition problems include regrouping. When the student successfully masters specific program objectives the reward is a problem solving game.
EVALUATION: *Arithmetic Teacher*, January, 1986.

CONCEPT: Addition
LEVEL: Grades 3 to 6
SOFTWARE TITLE: Computer EdGame Challenge: Dr. Oz's Cavern, Inchworm, Spell-Off
PUBLISHER: Verbatim Corporation
4966 El Camino Real, Suite 228
Los Altos, CA 94022
SUGGESTED PRICE: $3.50
HARDWARE: Apple II Series
DESCRIPTION: One side of this diskette contains a mathematical game, Dr. Oz's Cavern. Arithmetic problems are presented as the student moves through a series of four underground rooms. The game has nine skill levels and students have an option to choose the type and level of difficulty of the problems.
EVALUATION: *Arithmetic Teacher*, September, 1985.

ADDITION

CONCEPT:	Addition
LEVEL:	Grades 1 to 4
SOFTWARE TITLE:	Number Stomper
PUBLISHER:	The Learning Company 545 Middlefield Road Menlo Park, CA 94025
SUGGESTED PRICE:	
HARDWARE:	Apple II Series
DESCRIPTION:	Four instructional games are used to build and solve addition and subtraction problems. The numerals, 0 - 9, that students use in their equations are selected from rolling dice graphics.
EVALUATION:	*Arithmetic Teacher*, September, 1985.

CONCEPT:	Addition
LEVEL:	Grades K to 4
SOFTWARE TITLE:	Addition Magician
PUBLISHER:	Learning Company 545 Middlefield Road Menlo Park, CA 94025
SUGGESTED PRICE:	$34.95
HARDWARE:	Apple II Series; Commodore 64; IBM PC & PCjr
DESCRIPTION:	Addition Magician presents concepts in addition through color graphics and a game format. Students group numbers that equal selected sums.
EVALUATION:	*EPIE*, 1985.

CONCEPT:	Addition
LEVEL:	Grades 2 to 6
SOFTWARE TITLE:	Math Blaster
PUBLISHER:	Davidson and Associates 6069 Groveoak Place #12 Rancho Palos Verde, CA 90274
SUGGESTED PRICE:	$49.95
HARDWARE:	Apple II; IBM PC
DESCRIPTION:	Math blaster is a drill and practice program using math facts with numbers up to 20. The menu offers four games to practice the skills in addition, subtraction, multiplication and division. Five levels of difficulty are available for each basic operation, with higher level problems using fractions and decimals. A student option permits the user to create their own problems and use them in the program.
EVALUATION:	*Arithmetic Teacher*, March, 1985; *EPIE*, 1985.

CONCEPT:	Addition
LEVEL:	Grades 1 to 7
SOFTWARE TITLE:	Alien Addition
PUBLISHER:	Developmental Learning Materials One DLM Park Allen, TX 75002
SUGGESTED PRICE:	$44.00
HARDWARE:	Apple II Series; Commodore 64; IBM Series
DESCRIPTION:	Alien Addition is a drill and practice program that offers addition problems in an arcade-game format.
EVALUATION:	*Arithmetic Teacher*, March, 1985; *EPIE*, 1985.

CONCEPT:	Addition
LEVEL:	Grades 2 to 6
SOFTWARE TITLE:	The Arithmetic Classroom: Games
PUBLISHER:	Sterling Swift Publishing Company 7901 South IH-35 Austin, TX 78744
SUGGESTED PRICE:	$49.95
HARDWARE:	Apple II+, with paddle
DESCRIPTION:	The Arithmetic Classroom: Games is a drill and practice program that presents three speed games in all mathematic operations and fractions.
EVALUATION:	*Arithmetic Teacher*, October, 1984.

CONCEPT:	Addition
LEVEL:	Grades 2 to 6
SOFTWARE TITLE:	Prescriptive Math Drill
PUBLISHER:	Hartley Courseware 123 Bridge Street, Box 419 Dimondale, MI 48821
SUGGESTED PRICE:	$79.95
HARDWARE:	Apple II Series
DESCRIPTION:	Prescriptive Math Drill is a drill and practice program emphasizing addition and the other basic operations in mathematics. Program options allow the teacher to prescribe the entry and difficulty levels, and to specify the mastery score students need to continue on to the next drill.
EVALUATION:	*SECTOR*, April, 1982; *School Microware Reviews*, Winter, 1982; *MicroSIFT*, April, 1983.

ADDITION

CONCEPT:	Addition
LEVEL:	Grades 2 to 6
SOFTWARE TITLE:	Basic Number Facts: Practice
PUBLISHER:	Control Data Publishing Company P.O. Box 261127 San Diego, CA 92126
SUGGESTED PRICE:	$59.95
HARDWARE:	Apple II Series
DESCRIPTION:	Students become race car drivers and speed to improve their performance in the basic number facts. Students have the option to choose which operation they will practice. The score can be viewed at the completion of each race. Graphics are used throughout the program.
EVALUATION:	*Arithmetic Teacher*, April, 1985; *EPIE*, 1985; *MicroSIFT*, June, 1984.

CONCEPT:	Addition
LEVEL:	Grades 4 to 6
SOFTWARE TITLE:	Hey Taxi!
PUBLISHER:	Milton Bradley Company 443 Shaker Road East Longmeadow, MA 01028
SUGGESTED PRICE:	$39.00
HARDWARE:	Apple II Series
DESCRIPTION:	Hey Taxi! is a simulation-game of driving a taxi. Students drill and practice the basic facts through the calculation of fares and expenses they encounter on their shift as a taxi driver.
EVALUATION:	*Arithmetic Teacher*, February, 1985.

CONCEPT:	Addition
LEVEL:	Grades 1 to 6
SOFTWARE TITLE:	Challenge Math
PUBLISHER:	Sunburst Communications 39 Washington Avenue Pleasantville, NY 10570-9971
SUGGESTED PRICE:	$55.00
HARDWARE:	Apple II Series
DESCRIPTION:	Challenge Math is a drill and practice program presented in a three-game format which includes, Alien Intruder, Digitosaurus, and Math Mansion. This package reinforces basic math facts and teaches high-level skills, such as estimation and mental computation.
EVALUATION:	*Arithmetic Teacher*, September, 1984; *EPIE*, 1985; *Media Review*, June 1983.

CONCEPT: Addition
LEVEL: Grades 3 to 6
SOFTWARE TITLE: Whole Numbers: Practice
PUBLISHER: Control Data Publishing Company
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $59.95
HARDWARE: Apple II Series
DESCRIPTION: Whole Numbers: Practice, drills students in accuracy and speed in the basic number facts. The problems are presented in a game format similar to pinball. The package includes work sheets and a score sheet for student records.
EVALUATION: *Arithmetic Teacher*, April, 1985; *EPIE*, 1985.

CONCEPT: Addition
LEVEL: Grades 2 to 6
SOFTWARE TITLE: Carrying: Regrouping for Addition
PUBLISHER: Renaissance Learning Systems
Tecumseh Building
Jamesville, NY 13078
SUGGESTED PRICE:
HARDWARE: Apple II Series
DESCRIPTION: Carrying: Regrouping for Addition is an instructional support and drill and practice program. The program includes three disks: a Management option, a tutorial disk and a speed game.
EVALUATION: *Arithmetic Teacher*, March, 1986.

CONCEPT: Addition
LEVEL: Grades 1 to 4
SOFTWARE TITLE: Stickybear Math
PUBLISHER: XEROX, Computer Software Division
245 Longhill Rd.
Middletown, CT 06457
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Stickybear is an instructional support program that uses a bear character to explore the addition and subtraction concept with children. The program offers various difficulty levels and provides for storage of individual student progress.
EVALUATION: *EPIE*, 1985; *Classroom Computer Learning*, January 1984.

ADDITION

CONCEPT: Addition
LEVEL: Grades K to 4
SOFTWARE TITLE: Aliencounter/Face Flash
PUBLISHER: Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St. Louis, MO 63132-0579
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series
DESCRIPTION: Aliencounter and Face Flash are two drill and practice games. Concepts emphasized in Aliencounter include: counting, numeral recognition and readiness in addition and subtraction. Face Flash is a game using skills in memory, counting and basic numeration.

CONCEPT: Addition
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Basic Math Facts Drill
PUBLISHER: Random House
201 East 50th St.
New York, NY 10022
SUGGESTED PRICE: $66.00
HARDWARE: Apple II Series
DESCRIPTION: Basic Math Facts Drill is a drill and practice program emphasizing basic math facts in addition, subtraction, multiplication and division. The program is presented in lesson format with a game at the end of each lesson. Each lesson includes twenty exercises. Immediate correction is provided for the student. Scores appear at the end of each lesson and the program keeps track of those facts not mastered.
EVALUATION: *Courseware Report Card*, December, 1982; *California Library Media Consortium*, June, 1983.

CONCEPT: Addition
LEVEL: Grades K to 3
SOFTWARE TITLE: Fay: That Math Woman
PUBLISHER: Didatech
549-810 West Broadway
Vancouver, BC V524C9
SUGGESTED PRICE: $29.95
HARDWARE: Apple II Series
DESCRIPTION: Fay: That Math Woman is an instructional support program that assists students in understanding math operations. Fay is a screen character who uses the number line to illustrate addition, subtraction, multiplication and division.

CONCEPT: Addition
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Addition Circus
PUBLISHER: Gamco Industries
Box 310W23
Big Spring, TX 79721
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64; TRS-80 III
DESCRIPTION: Addition Circus is a drill and practice program that is presented in lesson format followed by a reward game. The teacher is provided a management system within the program which indicates the number, speed, and level of difficulty of the problems, and to activate or deactivate the arcade game.

CONCEPT: Addition
LEVEL: Grades K to 12
SOFTWARE TITLE: Multiploy
PUBLISHER: MicroMedia Publishing
6 Arrow Rd.
Ramsey, NJ 07446
SUGGESTED PRICE: $24.95
HARDWARE: Apple II Series
DESCRIPTION: Multiploy is a drill and practice program presented in an arcade-game format. Students choose from three difficulty levels of addition, subtraction, multiplication and division problems. The object of the game is to answer math problems as quickly and accurately as possible. Student scores and incorrect responses are shown at the end of each game. The scores are recorded for the teacher to evaluate student performance.
EVALUATION: *Electronic Learning*, March, 1983; *Educational Computer*, September, 1983.

CONCEPT: Addition
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Space Math
PUBLISHER: Learning Well
200 South Service Road
Roslyn Heights, NY 11577
SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series; IBM PC
DESCRIPTION: Space Math is a drill and practice program that uses a game format. Students compute math problems using addition, subtraction, multiplication and division. By correct responses the student is permitted to participate in a space game.

DECIMALS

CONCEPT: Decimals
LEVEL: Grades 4 to 7
SOFTWARE TITLE: Decimals: Addition and Subtraction
Decimals: Multiplication and Division
PUBLISHER: Gamco Industries
Box 310W23
Big Spring, TX 79721
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; TRS-80; Commodore 64
DESCRIPTION: Decimals is an instructional package that includes two decimal programs, one addition and subtraction, the other one multiplication and division.

CONCEPT: Decimals
LEVEL: Grade 4 to 8
SOFTWARE TITLE: The Arithmetic Classroom: Decimals
PUBLISHER: Sterling Swift Publishing Company
7901 South IH-35
Austin, TX 78744
SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series
DESCRIPTION: The Arithmetic Classroom: Decimals program contains five hierarchic lessons from concept development to the computation of decimals. The package provides instructional support with drill and practice of skills developed in the lesson. Students build on their competency and must pass lower levels before they are allowed to proceed in the program. Supplemental student workbooks and record forms accompany the package.
EVALUATION: *Arithmetic Teacher*, October, 1984.

CONCEPT: Decimals
LEVEL: Grades 4 to 8
SOFTWARE TITLE: Guinness World Records Math: Fractions, Decimals & Percent
PUBLISHER: Society for Visual Education, Inc.
1345 Diversey Parkway
Chicago, IL 60614
SUGGESTED PRICE: Apple disks $98.00; TRS-80 cassettes $85.00
HARDWARE: Apple II; TRS-80 Model I or III
DESCRIPTION: Guiness World Records Math is a drill and practice program recorded on two disks. The program presents problems for student mastery, using the basic operations in math with fractions and decimals. Problems on improper fractions and percent are also included in the package.
EVALUATION: *EPIE*, 1985; *The Mathematics Teacher*, February, 1984; *Classroom Computer Learning*, January, 1984; *Courseware Report Card*, June, 1983.

CONCEPT: Decimals
LEVEL: Grades 1 to 9
SOFTWARE TITLE: Galaxy Math Facts
PUBLISHER: Random House
201 East 50th St.
New York, NY 10022
SUGGESTED PRICE: $175.00
HARDWARE: Apple II Series
DESCRIPTION: Galaxy Math Facts is a drill and practice program set in a game format. The student must solve math problems correctly in order to return to earth. Problems include the following topics: place value, basic operations on whole numbers, integers, rounding and estimation, decimals and percents.
EVALUATION: *Electronic Learning*, January, 1983; *Curriculum Review*, May, 1983; *Courseware Report Card*, December, 1982.

CONCEPT: Decimals
LEVEL: Grades 1 to 9
SOFTWARE TITLE: Grand Prix
PUBLISHER: Random House
201 East 50th St.
New York, NY 10022
SUGGESTED PRICE: $175.00
HARDWARE: TRS-80
DESCRIPTION: Grand Prix is a drill and practice program set in a racing game format. Students are race car drivers, solving math problems to win the race. User options are available to the student to choose sequential levels of difficulty in math problems and driving course. Math topics presented in the game include: place value, decimals and percents, integers, rounding and estimation, and basic operations on whole numbers.
EVALUATION: *EPIE*, 1985.

CONCEPT: Decimals
LEVEL: Grades 4 to 6
SOFTWARE TITLE: Fractions/Decimals
PUBLISHER: Control Data
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $60.00 - Decimal disk only
HARDWARE: Apple II
DESCRIPTION: Fractions/Decimals is a drill and practice program presented in a dart game format. Increased levels of difficulty are available for students.

DECIMALS

CONCEPT:	Decimals
LEVEL:	Grades K to 6
SOFTWARE TITLE:	Mathematics Courseware Series
PUBLISHER:	Mindscape School Group 3444 Dundee Rd. Northbrook, IL 60062
SUGGESTED PRICE:	Basic Operations Set, 6 programs @ $195.00; Fractions and Decimals Set, 4 programs @ $130.00; Basic Numbers Set, 2 programs @ $65.00
HARDWARE:	Apple II Series; IBM PC
DESCRIPTION:	Mathematics Courseware is an instructional support program which includes topics on numbers, basic operations, fractions, and decimals. Skills in these areas are presented in lesson format. Concepts are introduced through the use of graphics and animation.

CONCEPT:	Decimals
LEVEL:	Grades 1 to 8
SOFTWARE TITLE:	Math Sequences
PUBLISHER:	Milliken Publishing Company 1100 Research Blvd. P.O. Box 21579 St. Louis, MO 63132-0579
SUGGESTED PRICE:	$450.00
HARDWARE:	Apple II Series; Atari
DESCRIPTION:	Math Sequences is a drill and practice package containing twelve areas covered in most school math curricula. The lessons are self-paced and provide students with correction and feedback. Assignments and mastery levels can be determined by the teacher on a class or individual basis. Progress graphs can be formulated from student performance records. Content areas on the twelve diskettes include: Number Readiness, Addition, Subtraction, Multiplication, Division, Laws of Arithmetic, Integers, Fractions, Decimals, Percents, and Measurement Formulas.
EVALUATION:	*EPIE*, 1985; *The Computing Teacher*, April 1982; *Classroom Computer News*, September, 1981.

CONCEPT: Decimals
LEVEL: Grades 4 to 8
SOFTWARE TITLE: Advanced Elementary Math Games
PUBLISHER: Control Data Publishing - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $59.95
HARDWARE: Commodore 64
DESCRIPTION: Advanced Elementary Math Games is a drill and practice program presented in a lesson and game format. Fifteen games are presented on four diskettes. Content areas include: Basic Math Operations, Fractions, Decimals, Percents, Prime Numbers, and Factors

CONCEPT: Decimals
LEVEL: Grades 6 to 8
SOFTWARE TITLE: Decimals, Percents, Ratios and Proportions
PUBLISHER: Milton Bradley Company
443 Shaker Road
East Longmeadow, MA 10128
SUGGESTED PRICE: $49.95 Decimals; $49.95 Percents
HARDWARE: Apple II Series
DESCRIPTION: Decimals and Percents, Ratios and Proportions are individual programs on separate disks presented in lesson format. Each program includes a readiness drill, instruction, practice, and a quiz. The programs also contain a record keeping system.

CONCEPT: Decimals
LEVEL: Grades 4 to 12
SOFTWARE TITLE: Elementary Math Mixer
PUBLISHER: Control Data Publishing - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series
DESCRIPTION: Elementary Math Mixer is a drill and practice program recorded on two disks. The first disk includes the program Money, Money, Money. Students count, make change, and compute with money. The second disk, Games of Chance, reinforce skills in reading decimals, skip counting, and the computation of whole numbers, decimals and integers.

DECIMALS

CONCEPT:	Decimals
LEVEL:	Grades 4 to 9
SOFTWARE TITLE:	Decimals - Addition and Subtraction
PUBLISHER:	Gamco Industries P.O. Box 310W23 Big Spring, TX 79721
SUGGESTED PRICE:	$39.95
HARDWARE:	Apple II Series; Commodore 64; TRS-80 III
DESCRIPTION:	Decimals - Addition and Subtraction is an instructional support program set up in a tutorial format. Students choose the skill and level of difficulty of problems they want to solve. Based on the number of correct responses, students are automatically placed at a higher or lower level of difficulty.

CONCEPT:	Decimals
LEVEL:	Grades 4 to 6
SOFTWARE TITLE:	Decimals - Multiplication and Division
PUBLISHER:	Gamco Industries P.O. Box 310W23 Big Spring, TX 79721
SUGGESTED PRICE:	$39.95
HARDWARE:	Apple II Series; Commodore 64; TRS-80 III
DESCRIPTION:	Decimals - Multiplication and Division is an instructional support program set up in a tutorial format. Students choose the skill and level of difficulty of problems they want to solve. Based on the number of correct responses, students are automatically placed at a higher or lower level of difficulty.

CONCEPT:	Decimals
LEVEL:	Grades 4 to 12
SOFTWARE TITLE:	Percentages Series
PUBLISHER:	Educational Activities P.O. Box 392 Freeport, NY 11520
SUGGESTED PRICE:	$59.95
HARDWARE:	Apple II Series; TRS-80
DESCRIPTION:	Percentages Series is a combination of a tutorial and drill program. Students are instructed and practice skills in converting decimals to percentages, and computing percents of whole numbers.

CONCEPT: Decimals
LEVEL: Grades 3 to 9
SOFTWARE TITLE: Decimal Dungeon
PUBLISHER: Unicom Software
297 Elmwood Ave.
Providence, RI 02907
SUGGESTED PRICE: $34.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Decimal Dungeon is a drill and practice program presented in a game format. Students are "held captive" in a dungeon and their only way of escape is to accurately add, subtract, multiply or divide decimal problems. The program provides explanations for correction if the student errs in computation.

CONCEPT: Decimals
LEVEL: Grades 3 to 12
SOFTWARE TITLE: Math Marvels
PUBLISHER: Houghton Mifflin
One Beacon Street
Boston, MA 02108
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; IBM PC
DESCRIPTION: Math Marvels is a drill and practice program that is presented in a three game format. Students use basic math operations to solve decimal problems.

CONCEPT: Decimals
LEVEL: Grades 5 to 9
SOFTWARE TITLE: Edu-ware Decimals
PUBLISHER: Edu-Ware Service, Inc.
P.O. Box 22222
Agoura, CA 91301
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64; IBM PC
DESCRIPTION: Edu-ware Decimals is an instructional support program that includes seven learning units. Content areas include: conversion, rounding, percentages, multiplication and division of decimals.

DIVISION

CONCEPT: Division
LEVEL: Grades 3 to 6
SOFTWARE TITLE: The Math Connection
PUBLISHER: Sunburst Communications
39 Washington Avenue
Pleasantville, NY 10570-9971
SUGGESTED PRICE: $49.00
HARDWARE: TRS-80 III
DESCRIPTION: Math Connection includes three drill and practice programs using a game format. Some student activities include mentally determining the remainder for an easy quotient, finding values for missing factors when the product is given, finding the value of the divisor or dividend when the quotient is given. Various levels of difficulty are available in some of the programs. Reproducible work sheets accompany the teacher's guide.
EVALUATION: *Arithmetic Teacher*, October, 1985.

CONCEPT: Division
LEVEL: Grades 3 to Adult
SOFTWARE TITLE: Math for All Ages: Division 1, 2, 3, and 4
PUBLISHER: Aquarius
P.O. Box 128
Indian Rocks Beach, FL 33535
SUGGESTED PRICE: $29.00 for each disk
HARDWARE: TRS-80 III
DESCRIPTION: Division 1, 2, 3, and 4 is a series consisting of four disks. These four programs provide drill and practice of whole numbers in division. Students are given options to choose the level of difficulty. The software package includes a management section for the teacher with the capability to save and retrieve student performance scores.
EVALUATION: *Arithmetic Teacher*, October, 1985.

CONCEPT: Division
LEVEL: Grades 4 to 10
SOFTWARE TITLE: Learning & Loving It! Division of Whole Numbers
PUBLISHER: Borns Software
19841 Sea Canyon Circle
Huntington Beach, CA 92648
SUGGESTED PRICE: $39.95
HARDWARE: Apple II+
DESCRIPTION: Learning and Loving It! Division of Whole Numbers is a drill and practice program that will allow the student to choose the level of difficulty and the number of digits in the division problem. The student can use short or long division in computing the response. Options in this division program include a help command and a timed game on division facts.
EVALUATION: *Mathematics Teacher*, January, 1985.

CONCEPT:	Division
LEVEL:	Grades 3 to 12
SOFTWARE TITLE:	Fundamentals of Mathematics
PUBLISHER:	Sterling Swift Publishing Company 7910 S. IH-35 Austin, TX 78744
SUGGESTED PRICE:	Complete set $249.95; Individual Sets $69.95, 3rd, 5th, and 9th grades
HARDWARE:	Commodore 64; PET; Apple II Series
DESCRIPTION:	Fundamental of Mathematics is an instructional support program presented in a lesson format. Each of the eighty-nine lessons presented in this program are math concepts that are generally offered in the elementary through highschool math curriculum. Each lesson includes a tutorial, drill, and test. Several levels of test difficulty are available. Work sheets are an optional feature to use in conjunction with the computer lessons.
EVALUATION:	*Arithmetic Teacher*, January, 1985.

CONCEPT:	Division
LEVEL:	Grades 2 to 6
SOFTWARE TITLE:	Math Blaster
PUBLISHER:	Davidson and Associates 6069 Groveoak Place #12 Ranch Palos Verde, CA 90274
SUGGESTED PRICE:	$49.95
HARDWARE:	Apple II Series; IBM PC
DESCRIPTION:	Math Blaster is a drill and practice program using math facts with numbers up to 20. Math problems are offered through four activities, stressing skills in addition, subtraction, multiplication and division. Students have options to choose problems from a range of five levels of difficulty or to create their own problems and insert them into the program. Higher level math problems use the operations on decimals and fractions.
EVALUATION:	*Arithmetic Teacher*, March, 1985; *EPIE*, 1985; *InfoWorld*, July 11, 1983; *Courseware Report Card*, December, 1983.

DIVISION

CONCEPT:	Division
LEVEL:	Grades 3 to 7
SOFTWARE TITLE:	Demolition Division
PUBLISHER:	Developmental Learning Materials One DLM Park Allen, TX 75002
SUGGESTED PRICE:	$44.00
HARDWARE:	Apple II Series; Commodore 64; IBM PC Series
DESCRIPTION:	Demolition Division is a drill and practice program on division facts. The numbers in the answers range from 0 - 9. Problems are presented in a game format. Demolition Division is one program in the Arcademic Skill Builders in Math Series.
EVALUATION:	*Arithmetic Teacher*, March, 1985; *Media Review*, February, 1983; *Courseware Report Card*, September, 1982.

CONCEPT:	Division
LEVEL:	Grades 3 to 6
SOFTWARE TITLE:	Dragon Mix
PUBLISHER:	Developmental Learning Materials One DLM Park Allen, TX 75002
SUGGESTED PRICE:	$44.00
HARDWARE:	Apple II Series; Commodore 64; IBM PC Series
DESCRIPTION:	Dragon Mix is a drill and practice program on division and multiplication facts. The problems are presented in a game format. Students are provided with the answers for self correction. Dragon Mix is one program in the Arcademic Skill Builders in Math Series.
EVALUATION:	*Arithmetic Teacher*, March, 1985; *MicroSIFT*, May, 1983; *Educational Technology*, November, 1982.

CONCEPT:	Division
LEVEL:	Grades 1 to 6
SOFTWARE TITLE:	Basic Number Facts
PUBLISHER:	Control Data Publishing-Plato P.O. Box 261127 San Diego, CA 92126
SUGGESTED PRICE:	$39.95
HARDWARE:	Apple IIe, II+; Atari 800; TI 99/4A; IBM PC
DESCRIPTION:	Basic Number Facts is a drill and practice program presented in four lessons through a game format resembling a car race. Students can choose to solve problems in addition, subtraction, multiplication, and division. Levels of difficulty levels increase as students master the operations. Teachers are offered a record keeping system.
EVALUATION:	*EPIE*, 1985; *MicroSIFT*, June, 1984.

CONCEPT: Division
LEVEL: Grades 3 to 9
SOFTWARE TITLE: Whole Numbers
PUBLISHER: Control Data -Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $39.95
HARDWARE: Apple IIe/II+; Atari 800; TI 99/4A; IBM PC
DESCRIPTION: Whole Numbers is a drill and practice program presented in five lessons through a game resembling pinball. Students compute answers to problems in addition, subtraction, multiplication, division and mixed operations. Student summary performances are recorded for the teacher.
EVALUATION: *EPIE*, 1985.

CONCEPT: Division
LEVEL: Grades 2 to 6
SOFTWARE TITLE: Frenzy/Flip Flop
PUBLISHER: Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St. Louis, MO 63132-0579
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Frenzy/Flip Flop are two programs presented on one disk. Frenzy drills students on basic subtraction and division facts in a game format. Flip Flop in an instructional support program on transformational geometry.

CONCEPT: Division
LEVEL: Grades K to 3
SOFTWARE TITLE: Fay: That Math Woman
PUBLISHER: Didatech
549-810 West Braodway
Vancouver, BC V424C9
SUGGESTED PRICE: $29.95
HARDWARE: Apple II Series
DESCRIPTION: Fay: That Math Woman is an instructional support program that assists students in understanding the math operations. Fay is a screen character who uses the number line to illustrate addition, subtraction, multiplication and division.

DIVISION

CONCEPT:	Division
LEVEL:	Grades 1 to 6
SOFTWARE TITLE:	Basic Math Facts Drill
PUBLISHER:	Random House 201 East 50th St. New York, NY 10022
SUGGESTED PRICE:	$66.00
HARDWARE:	Apple II Series
DESCRIPTION:	Basic Math Facts Drill is a drill and practice program emphasizing basic math facts. The program is presented in lesson format with a game at the end of each lesson. Each lesson includes twenty exercises using basic math facts. Immediate correction is provided for the student. Scores appear at the end of each lesson and the program keeps track of facts not mastered.
EVALUATION:	*Courseware Report Card*, December, 1982; *California Library Media Consortium*, June, 1983.

CONCEPT:	Division
LEVEL:	Grades 1 to 6
SOFTWARE TITLE:	Division Shooting Gallery
PUBLISHER:	Gamco Industries P.O. Box 310W23 Big Spring, TX 79721
SUGGESTED PRICE:	$39.95
HARDWARE:	Apple II Series; Commodore 64; TRS-80 III
DESCRIPTION:	Division Shooting Gallery is a drill and practice program that is presented in lesson format followed by a reward game. The teacher has a management system within the program to indicate the number, speed and level of difficulty of the problems, and to incorporate the reward game. The game is set up like a shooting gallery. Students try to answer the questions on division facts correctly, each correct reply shoots down the duck that contains the problem.

CONCEPT: Division
LEVEL: Grades K to 12
SOFTWARE TITLE: Multiploy
PUBLISHER: MicroMedia Publishing
6 Arrow Rd.
Ramsey, NJ 07446
SUGGESTED PRICE: $24.95
HARDWARE: Apple II Series
DESCRIPTION: Multiploy is a drill and practice program presented in an arcade-game format. Students choose from three levels of difficulty in addition, subtraction, multiplication and division problems. The object of the game is to quickly and accurately answer math problems. Scores and incorrect responses are shown at the end each game. Student scores are recorded in the program for the teacher to evaluate performance.
EVALUATION: *Electronic Learning*, March, 1983; *Educational Computer*, September, 1983.

CONCEPT: Division
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Space Math
PUBLISHER: Learning Well
200 South Service Road
Roslyn Heights, NY 11577
SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series; IBM PC
DESCRIPTION: Space Math is a drill and practice program that uses a game format. Students compute math problems using addition, subtraction, multiplication, and division. Correct responses allow the student to participate in a space game.

ESTIMATION

CONCEPT:	Estimation
LEVEL:	Grades 3 to 6.
SOFTWARE TITLE:	Estimation Skill Builder
PUBLISHER:	EduSoft P.O. Box 2560 Berkeley, CA 94702
SUGGESTED PRICE:	$29.95
HARDWARE:	Apple II, IIe
DESCRIPTION:	The program is presented in a timed-game format. Students will be able to choose types of problems (addition, subtraction, multiplication, division) and the level of difficulty. The student has the option to play the game individually or with a partner. A cumulative score appears after each game.
EVALUATION:	*Arithmetic Teacher*, March, 1985; *Courseware Report Card*, September, 1982; *The Computing Teacher*, October 1981.

CONCEPT:	Estimation
LEVEL:	Grades 2 to 6
SOFTWARE TITLE:	Challenge Math
PUBLISHER:	Sunburst Communications 39 Washington Avenue Pleasantville, NY 10570-9971
SUGGESTED PRICE:	$59.00
HARDWARE:	Apple II Series
DESCRIPTION:	This package includes three programs that challenge students to compute and estimate in whole numbers and decimals. Challenge Math is presented in a game format with a teacher option to regulate the levels of difficulty of the problems.
EVALUATION:	*Arithmetic Teacher*, September, 1984; *Media Review*, June, 1983; *EPIE*, 1985.

CONCEPT:	Estimation
LEVEL:	Grades K to 1
SOFTWARE TITLE:	Micros for Micros: Estimation
PUBLISHER:	Math and Computer Education Project Lawrence Hall of Science University of California Berkeley, CA 94720
SUGGESTED PRICE:	$34.95
HARDWARE:	Apple II Series
DESCRIPTION:	This program offers younger children three game-like activities that will enhance different estimation abilities.
EVALUATION:	*Arithmetic Teacher*, April, 1985.

CONCEPT: Estimation
LEVEL: Grades 5 to 12
SOFTWARE TITLE: Math Strategies: Estimation
PUBLISHER: Science Research Associated, Inc. (SRA)
55 North Wacker Drive
Chicago, IL 60606
SUGGESTED PRICE: $95.00
HARDWARE: Apple II Series
DESCRIPTION: Math Strategies: Estimation is a program that combines the use of a student text and the computer. Tutorials and games are the instructional vehicles by which students learn estimation skills. Estimation activities include the use of basic math operations on whole and decimal numbers.

CONCEPT: Estimation
LEVEL: Grades 3 to 5
SOFTWARE TITLE: Elementary Volume 1 - Mathematics: Games and Drills
PUBLISHER: Minnesota Educational Computing Consortium (MECC)
3490 Lexington Avenue North
St. Paul, MN 55112
SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series
DESCRIPTION: Mathematics: Games and Drills includes eleven programs presented in lesson and game formats. Topics in the lessons include metric system, rounding numbers, factoring, and the coordinate system. Teacher have optional control of time limits for speed drills. Work sheets are included for students to record drill scores.

FACTORING

CONCEPT: Factoring
LEVEL: Grades 6 to 8
SOFTWARE TITLE: Factoring Whole Numbers
PUBLISHER: Quality Educational Designs
P.O. Box 12486
Portland, OR 97212-0486
SUGGESTED PRICE: $90.00
HARDWARE: Commodore 64
DESCRIPTION: Factoring Whole Numbers is an interactive tutorial program recorded on three diskettes. The program offers hierarchic lessons in factor pairs, primes and composites, exponents and greatest common factors. Each topic is divided into a tutorial and a game or contest. Students have the option to choose the level of difficulty and set the speed of performance.
EVALUATION: *Arithmetic Teacher*, October, 1985.

CONCEPT: Factoring
LEVEL: Grades 4 to 8
SOFTWARE TITLE: Advanced Elementary Math Games
PUBLISHER: Control Data Publishing - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $59.95
HARDWARE: Commodore 64
DESCRIPTION: Advanced Elementary Math Games is a drill and practice program presented in lesson and game format. Fifteen games are presented on four diskettes. Content areas include: Basic Math Operations, Fractions, Decimals, Percents, Prime Numbers and Factors.

CONCEPT: Factoring
LEVEL: Grades 3 to 6
SOFTWARE TITLE: Sum Ducks
PUBLISHER: Spinnaker Software
215 First St.
Cambridge, MA 02142
SUGGESTED PRICE: $34.95
HARDWARE: Apple II Series
DESCRIPTION: Sum Ducks is a series of games allowing students to practice skills in factoring, finding prime numbers, and creating multiples.

CONCEPT:	Factoring
LEVEL:	Grades 3 to 5
SOFTWARE TITLE:	Elementary Volume 1 - Mathematics: Games and Drills
PUBLISHER:	Minnesota Educational Computing Consortium (MECC) 3490 Lexington Avenue North St. Paul, MN 55112
SUGGESTED PRICE:	$49.95
HARDWARE:	Apple II Series
DESCRIPTION:	Mathematics: Games and Drills includes eleven programs presented in lesson and game formats. Topics in the lessons include metric system, rounding numbers, factoring, and the coordinate system. Teacher have optional control of the time limits for speed drills. Work sheets are included for students to record scores from the drills.

CONCEPT:	Factoring
LEVEL:	Grades 4 to 9
SOFTWARE TITLE:	Fractions, Factors and Multiples
PUBLISHER:	Micro Ed P.O. Box 44400 S. Eden Prairie, MN 55344
SUGGESTED PRICE:	$68.00 PET; $71.00 Commodore 64
HARDWARE:	PET; Commodore 64
DESCRIPTION:	Fractions, Factors, and Multiples is an instructional support program presented in game format. Skills that students will learn include finding fractional and decimal equivalents, the lowest common denominator, determining the greatest common factor, and common multiples. A summary of student performance is displayed at the end of each game.

FRACTIONS

CONCEPT:	Fractions
LEVEL:	Grades 3 to 5
SOFTWARE TITLE:	Recognizing Fractions
PUBLISHER:	Teacher's Pet Software 1517 Holly St. Berkeley, CA 94703
SUGGESTED PRICE:	$27.95
HARDWARE:	PET, Cassette
DESCRIPTION:	Recognizing Fractions is a drill and practice program that uses pictures to assist students in recognizing and naming proper fractions. Denominators less than 25 are used.
EVALUATION:	*Arithmetic Teacher*, December, 1984.

CONCEPT:	Fractions
LEVEL:	Grades 6 to 8
SOFTWARE TITLE:	Fraction Flip
PUBLISHER:	Southwest EdPsych Services 6342 W. Bell Rd. Glendale, AZ 85308
SUGGESTED PRICE:	$39.95
HARDWARE:	Apple II Series
DESCRIPTION:	Fraction Flip is a drill and practice program centering around the skills of recognizing and identifying equivalents in fractions and decimals. The format is similar to a memory game such as Concentration. Student options include selecting the level of difficulty of the game and the number of players that will participate. Performance scores of all the players can be tallied and printed for the teacher and participants.
EVALUATION:	*Arithmetic Teacher*, December, 1985.

CONCEPT:	Fractions
LEVEL:	Grades 2 to 8
SOFTWARE TITLE:	Early Games - Fraction Factory
PUBLISHER:	Springboard 7807 Creekbridge Circle Minneapolis, MN 55435
SUGGESTED PRICE:	$29.95
HARDWARE:	Apple II Series; Commodore 64; IBM PC PCjr
DESCRIPTION:	Early Games - Fraction Factory is a learning game that aids the student in understanding the basic concepts in fractions. The learning games will further expose students to fraction concepts introduced in the lower grade levels.
EVALUATION:	*MicroSIFT*, June, 1984.

CONCEPT: Fractions
LEVEL: Grades 4 to 6
SOFTWARE TITLE: Fractions/Decimals
PUBLISHER: Control Data
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $60.00
HARDWARE: Apple II
DESCRIPTION: Fractions/Decimals is a drill and practice program presented in a dart game format. Increased levels of difficulty are available for students.

CONCEPT: Fractions
LEVEL: Grades 4 to 8
SOFTWARE TITLE: Fraction Action
PUBLISHER: Unicom Software
297 Elmwood Ave.
Providence, RI 02907
SUGGESTED PRICE: $34.95
HARDWARE: Apple II Series; Commodore 64; IBM PC &PCjr
DESCRIPTION: Fraction Action is a drill and practice program that is presented in a game format. Students are held captive until they complete math operations on fractional numbers. There are various levels of difficulty available. One or two players can participate in the game.

CONCEPT: Fractions
LEVEL: Grades 3 to 7
SOFTWARE TITLE: Fractions: Terminology and Concepts
Fractions: Addition and Subtraction
Fractions: Multiplication and Division
PUBLISHER: Control Data Publishing Company
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $49.95 for each program
HARDWARE: IBM PC; TI 99/4A
DESCRIPTION: Each program is on an individual diskette. The skills in each are presented in five tutorial lessons for the student.

FRACTIONS

CONCEPT: Fractions
LEVEL: Grades 4 to 8
SOFTWARE TITLE: Fraction Fuel-Up
PUBLISHER: Developmental Learning Materials
One DLM Park
Allen, TX 75002
SUGGESTED PRICE: $29.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Fraction Fuel-Up is a drill and practice program presented in a game format. In the game students supply answers to fraction problems to complete their journey in space. Some management options are available for the student.

CONCEPT: Fractions
LEVEL: Grades 4 to 10
SOFTWARE TITLE: Fractions Package
PUBLISHER: Micro-Ed
P.O. Box 444005
Eden Prairie, MN 55344
SUGGESTED PRICE: $99.00
HARDWARE: Commodore 64; PET cassette; PET disk
DESCRIPTION: Fractions Package is a set of seven learning programs that start with concept building in fractions. The programs build on the relationship of the fraction to the whole, and build to more difficult problems in equivalent fractions, mixed and improper fractions, and adding and subtracting mixed numbers.

CONCEPT: Fractions
LEVEL: Grades 1 to 10
SOFTWARE TITLE: Fraction and Mixed Number Recognition
PUBLISHER: EduSoft
P.O. Box 2560
Berkeley, CA 94702
SUGGESTED PRICE: $29.95
HARDWARE: Apple II Series; Atari
DESCRIPTION: Fraction and Mixed Number Recognition is an instructional support program designed for students with varying degrees of competency in fractions. The program introduces fractional recognition, uses screen graphics, and advances toward recognizing combinations of whole and fractional parts.
EVALUATION: *The Computing Teacher*, Vol. 8, Number 3; *MicroSIFT*, January, 1982.

CONCEPT: Fractions
LEVEL: Grades 3 to 9
SOFTWARE TITLE: Fraction Action
PUBLISHER: Control Data - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $49.95
HARDWARE: Apple IIe, II+
DESCRIPTION: Fraction Action is a drill and practice program presented in a lesson format. Two disks present basic concepts in fractions and basic computation in fractions.

CONCEPT: Fractions
LEVEL: Grades 4 to 8
SOFTWARE TITLE: Guiness World Records Math: Fractions, Decimals & Percent
PUBLISHER: Society for Visual Education, Inc.
1345 Diversey Parkway
Chicago, IL 60614
SUGGESTED PRICE: Apple disks - $98.00; TRS-80 Cassettes - $85.00
HARDWARE: Apple II; TRS-80, Model I, III
DESCRIPTION: Guiness World Records Math is a drill and practice program recorded on two disks. The program presents problems for student mastery using basic math operations on fractions and decimals. Problems on improper fractions are included.
EVALUATION: *Educational Computer*, October, 1983; *California Library Media Consortium*, June, 1983.

CONCEPT: Fractions
LEVEL: Grades 4 to 6
SOFTWARE TITLE: Fractions
PUBLISHER: Control Data - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $39.95
HARDWARE: Apple IIe II+; Atari 800; TI 99/4A; IBM PC
DESCRIPTION: Fractions is a drill and practice program presented in a dart game format. Included are ten levels of difficulty in recognizing fractional intervals.

FRACTIONS

CONCEPT: Fractions
LEVEL: Grades K to 6
SOFTWARE TITLE: Mathematics Courseware Series
PUBLISHER: Mindscape School Group
3444 Dundee Rd.
Northbrook, IL 60062
SUGGESTED PRICE: Basic Operations Set, 6 programs @ $195.00; Fractions and Decimals Set, 4 programs @ $130.00; Basic Numbers Set, 2 programs @ $65.00.
HARDWARE: Apple II Series; IBM PC
DESCRIPTION: Mathematics Courseware is an instructional support program including topics on numbers, basic operations, fractions, and decimals. Skills in these topic areas are presented in lesson format. Concepts are introduced through the use of graphics and animation.

CONCEPT: Fractions
LEVEL: Grades 4 to 8
SOFTWARE TITLE: Advanced Elementary Math Games
PUBLISHER: Control Data Publishing - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $59.95
HARDWARE: Commodore 64
DESCRIPTION: Advanced Elementary Math Games is a drill and practice program presented in a lesson and game format. Fifteen games are presented on four diskettes. The following content areas are included: Basic Math Operations, Fractions, Decimals, Percents, Prime Numbers, and Factors.

CONCEPT: Fractions
LEVEL: Grades 4 to 9
SOFTWARE TITLE: Battling Bugs/Concentration
PUBLISHER: Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St. Louis, MO 63132-0579
SUGGESTED PRICE: $32.95
HARDWARE: Apple II Series
DESCRIPTION: Battling Bugs and Concentration are two programs presented in a game format. Battling Bugs reinforces the concept of positive and negative numbers. In Concentration, the object of the game is for students to identify and match equivalent fractions.

CONCEPT: Fractions
LEVEL: Grades 1 to 8
SOFTWARE TITLE: Math Sequences
PUBLISHER: Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St. Louis, MO 63132-0579
SUGGESTED PRICE: $450.00
HARDWARE: Apple II Series; Atari
DESCRIPTION: Math Sequences is a drill and practice package containing twelve content areas covered in most math curriculums. The lessons are self-paced and provide students with correction and feedback. Assignments and mastery levels can be determined by the teacher on a class or individual basis. Progress graphs can be made from student performance records. Following are the content areas included on the twelve diskettes: Number Readiness, Addition, Subtraction, Multiplication, Division, Laws of Arithmetic, Integers, Fractions, Decimals, Percents, and Measurement Formulas.
EVALUATION: *EPIE*, 1985; *MicroSIFT*, October, 1981; *The Computing Teacher*, April, 1982; *Classroom Computer News*, October, 1981.

CONCEPT: Fractions
LEVEL: Grades 3 to 9
SOFTWARE TITLE: Fraction Action
PUBLISHER: Unicom Software
297 Elmwood Ave.
Providence, RI 02907
SUGGESTED PRICE: $34.95
HARDWARE: Apple II Series; TRS-80
DESCRIPTION: Fraction Action is a drill and practice program presented in a game format. Students are "held captive" in the basement of a mansion and their only escape is to respond accurately to addition, subtraction, multiplication and division of fraction problems. The program provides explanations for error correction.

FRACTIONS

CONCEPT:	Fractions
LEVEL:	Grades 4 to 9
SOFTWARE TITLE:	Fractions, Factors, and Multiples
PUBLISHER:	Micro Ed P.O. Box 444005 Eden Prairie, MN 55344
SUGGESTED PRICE:	$68.00 -PET; $71.00 Commodore 64
HARDWARE:	PET; Commodore 64
DESCRIPTION:	Fractions, Factors, and Multiples is an instructional support program presented in a game format. Skills that students will learn include: fraction and decimal equivalents, finding the lowest common denominator, determining the greatest common factor, and common multiples. A summary of student performance is displayed after each game.

CONCEPT:	Fractions
LEVEL:	Grades 4 to 7
SOFTWARE TITLE:	Pizza Fractions
PUBLISHER:	Human Relations Media - HRM 175 Tompkins Ave. Pleasantville, NY 10570
SUGGESTED PRICE:	$49.00
HARDWARE:	Apple II Series
DESCRIPTION:	Pizza Fractions is a drill and practice program presented in a game format. Students play the role of working in a pizza parlor, and slice the pizza into the fractional pieces that the customer wants. Five levels of difficulty are available from which students may choose.

CONCEPT: Geometry
LEVEL: Grades 3 to 6
SOFTWARE TITLE: Understanding Points and Angles: Geometry Basics
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
SUGGESTED PRICE: $35.00
HARDWARE: Apple II Series
DESCRIPTION: This program includes two tutorials sequenced to introduce students to nonmetric geometry. The lessons include definitions and graphics of points, lines, and angles. The tutorials are paced by the responses of the individual students. Work sheets can be reproduced by the teacher for further practice.

CONCEPT: Geometry
LEVEL: Grades 4 to 6
SOFTWARE TITLE: Understanding Lines and Triangles: Geometry Basics
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
SUGGESTED PRICE: $47.52
HARDWARE: Apple II Series
DESCRIPTION: Understanding Lines and Triangles is a tutorial on the concepts of lines and types of triangles. Each lesson is followed by a ten question quiz. The questions for the quiz are randomly generated by the computer. Student handouts accompany this package.
EVALUATION: *Arithmetic Teacher*, November, 1984.

CONCEPT: Geometry
LEVEL: Grades 2 to 7
SOFTWARE TITLE: Micro Math Magic: Geometry and Measurement
PUBLISHER: Deegan Learning Materials
P.O. Box 245
Mankato, MN 56001
SUGGESTED PRICE: $32.95
HARDWARE: Apple II Series
DESCRIPTION: Geometry and Measurement, part of the Micro Math Magic Series, is an instructional support program introducing students to the concepts of geometry and measurement.

GEOMETRY

CONCEPT: Geometry
LEVEL: Grades Preschool to 3
SOFTWARE TITLE: EZ Logo
PUBLISHER: Minnesota Educational Computing Consortium (MECC)
3490 Lexington Ave. North
St. Paul, MN 55112
SUGGESTED PRICE: $48.00
HARDWARE: Apple II Series
DESCRIPTION: EZ Logo prepares young children to learn Logo. Activities are presented to promote control of the turtle.
EVALUATION: *Arithmetic Teacher*, September, 1984; *EPIE*, 1985.

CONCEPT: Geometry
LEVEL: Grades 3 to 6
SOFTWARE TITLE: Learning Through Logo
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
SUGGESTED PRICE: $49.00
HARDWARE: Apple II Series
DESCRIPTION: Learning Through Logo is a package which familiarizes beginners with the language and commands of Logo. The student will become involved in problem solving strategies and create pictures on the screen. The pictures students create build and reinforce concepts in geometry.

CONCEPT: Geometry
LEVEL: Grades 3 to 12
SOFTWARE TITLE: Turtle Tracks
PUBLISHER: Scholastic Software
P.O. Box 7502
2931 East McCarty Street
Jefferson City, MO 65102
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series
DESCRIPTION: Turtle Tracks introduces the student to the Logo language and easy commands that will help the student to create shapes, patterns, and pictures. The student slowly becomes involved in programming.

CONCEPT: Geometry
LEVEL: Grades 2 to 12
SOFTWARE TITLE: Getting Started with Logo
PUBLISHER: Developmental Learning Materials
One DLM Park
Allen, TX 75002
SUGGESTED PRICE: $52.00
HARDWARE: Apple II Series
DESCRIPTION: Getting Started with Logo is an instructional support program for the beginner who wants to learn the logo language, and create graphics. The package includes a complete training manual, blackline master sheets, and activities for the classroom run off the computer.

CONCEPT: Geometry
LEVEL: Grades 4 to 6
SOFTWARE TITLE: Golf Classic and Compubar
PUBLISHER: Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St. Louis, MO 63132-0579
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series
DESCRIPTION: Golf Classic and Compubar are drill and practice programs set in a game format. Golf Classic asks students to identify the degree of the angle they wants their golf ball to travel on a simulated golf course. Compubar involves students in reading graphs and mentally computing the values involved in the bar graph.
EVALUATION: *Arithmetic Teacher*, October, 1984.

CONCEPT: Geometry
LEVEL: Grades 4 to 8
SOFTWARE TITLE: Tanagrams
PUBLISHER: Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St Louis, MO 63132-0579
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series
DESCRIPTION: Tanagrams is a program that provides students with a picture or pattern on the screen and directs them to recreate it from seven different polygon shapes cut from cardboard. The program utilizes the computer and "hands on" learning materials.

GEOMETRY

CONCEPT: Geometry
LEVEL: Grades 1 to 5
SOFTWARE TITLE: Trap-A-Zoid
PUBLISHER: Designware
185 Berry Street, #3-158
San Francisco, CA 94107
SUGGESTED PRICE: $39.95
HARDWARE:
DESCRIPTION: Trap-A-Zoid is a drill and practice program presented in a game format. Students apply and practice their knowledge of geometric shapes by drawing them with the keyboard or joystick. The object of this game is to trap little creatures in shapes the students draw. Various levels of difficulty are available.
EVALUATION: *EPIE*, 1985.

CONCEPT: Geometry
LEVEL: Grades 4 to 6
SOFTWARE TITLE: Quadrilaterals
PUBLISHER: Minnesota Educational Computing Consortium (MECC)
3490 Lexington Ave. North
St. Paul, MN 55112
SUGGESTED PRICE: $48.60
HARDWARE: Apple II Series
DESCRIPTION: Quadrilaterals contains two tutorial programs emphasizing instruction on identifying quadrilaterals and developing formulas for computing perimeter and area of quadrilaterals. Quizzes are built into the lessons to assess student mastery.

CONCEPT: Geometry
LEVEL: Grades K to 12
SOFTWARE TITLE: Terrapin Logo Version 2.0
PUBLISHER: Terrapin, Incorporated
380 Green St.
Cambridge, MA 02139
SUGGESTED PRICE: $99.00 - 2 disks
HARDWARE: Apple II Series
DESCRIPTION: Terrapin Logo is an instructional program that will teach the Logo language. The program begins instruction with simple graphic commands and progresses to teach a programming language. Students use the logo commands to program and build shapes.
EVALUATION: *Electronic Learning*, March, 1983.

CONCEPT: Geometry
LEVEL: Grades 6 to 9
SOFTWARE TITLE: Geometry and Measurement
PUBLISHER: Control Data - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $49.94
HARDWARE: Apple IIe, II+
DESCRIPTION: Geometry and Measurement is an instructional support program recorded on two disks. Seven concepts relating to geometry and measurement are presented in a lesson format. Several levels of difficulty are included.

CONCEPT: Geometry
LEVEL: Grades 2 to 6
SOFTWARE TITLE: Frenzy/Flip Flop
PUBLISHER: Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St. Louis, MO 63132-0579
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Frenzy/Flip Flop are two programs presented on one disk. Frenzy is a drill and practice program presented in a game format. Students answer questions on basic math facts in subtraction and division. Flip Flop is an instructional support program emphasizing transformational geometry. Students view two shapes on the screen and figures out how the shape on the left can be adjusted to look like the shape on the right.

CONCEPT: Geometry
LEVEL: Grades 4 to 9
SOFTWARE TITLE: Arith-Magic II
PUBLISHER: Quality Educational Designs
P.O. Box 12486
Portland, OR 97212
SUGGESTED PRICE: $35.00
HARDWARE: Apple II Series
DESCRIPTION: Arith-Magic II includes seven programs on one disk. The programs are presented in game and tutorial format and provide instructional support for students learning about area and perimeter.
EVALUATION: *Educational Technology*, May, 1982; *MicroSIFT*, June, 1982; *Educational Computer*, April, 1982.

GRAPHING

CONCEPT: Graphing
LEVEL: Grades Preschool to 4
SOFTWARE TITLE: Bumble Games
PUBLISHER: Learning Company
545 Middlefield Rd.
Menlo Park, CA 94125
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64; Atari 800
DESCRIPTION: Bumble Games consists of a series of six games that teach children to plot numbers and find locations on a grid-like map. Bumble is a character who assists students through the self-paced games.
EVALUATION: *Curriculum Review*, August, 1983; *MicroSIFT*, May 1983; *Courseware Report Card*, December, 1982.

CONCEPT: Graphing
LEVEL: Grades Preschool to 4
SOFTWARE TITLE: Bumble Plot
PUBLISHER: Learning Company
545 Middlefield Rd.
Menlo Park, CA 94125
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Bumble Plot includes a series of five games centered around a theme of locating robbers and treasures underwater, using positive and negative numbers. The program builds on concepts introduced in Bumble Games and teaches users to plot their own numbers and produce computer graphics.
EVALUATION: *MicroSIFT*, May 1983; *Courseware Report Card*, December, 1982.

CONCEPT: Graphing
LEVEL: Grades 3 to Adult
SOFTWARE TITLE: Algebra Arcade
PUBLISHER: Wadsworth Electronic Publishing Company
10 Davis Dr.
Belmont, CA 94002

SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series
DESCRIPTION: Algebra Arcade is an instructional gaming program that accommodates one or two players. The object of the game is to plot a path that will touch characters that have been scattered on X and Y axis. Students will accumulate a score as they successfully locate the characters called Algebroids.

CONCEPT: Graphing
LEVEL: Grades 3 to 5
SOFTWARE TITLE: Elementary Volume 1 - Mathematics: Games and Drills
PUBLISHER: Minnesota Educational Computing Consortium (MECC)
3490 Lexington Ave. North
St. Paul, MN 55112
SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series
DESCRIPTION: Mathematics: Games and Drills includes eleven programs presented in a lesson and game format. Topics included in the lesson: metric system, rounding numbers, factoring and the coordinate system. The teacher has optional control of the time limits for speed drills. Work sheets are included for students to record scores from the drills.

CONCEPT: Graphing
LEVEL: Grades 3 to 4
SOFTWARE TITLE: Exploring Tables and Graphs
PUBLISHER: Weekly Reader
1250 Fairwood Ave. P.O. Box 16759
Columbus, OH 43216
SUGGESTED PRICE: $34.95
HARDWARE: Apple II Series
DESCRIPTION: Exploring Tables and Graphs is an instructional game program that teaches skills in reasoning and problem solving. A variety of graphs are used in games to encourage the development of these skills in students.

CONCEPT: Graphing
LEVEL: Grades 3 to 9
SOFTWARE TITLE: Easy Graph
PUBLISHER: Grolier Electronic Publishing, Inc.
95 Madison Ave.
New York, NY 10016
SUGGESTED PRICE: $29.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Easy Graph is a tutorial program that teaches students concepts in graphing. A variety of graph types are used in the program.

INTEGERS

CONCEPT: Integers
LEVEL: Grades 1 to 9
SOFTWARE TITLE: Galaxy Math Facts
PUBLISHER: Random House
201 East 50th St.
New York, NY 10022
SUGGESTED PRICE: $175.00
HARDWARE: Apple II Series
DESCRIPTION: Galaxy Math Facts is a drill and practice program presented in a space game format. The student must solve math problems correctly to return to earth. The following topics are emphasized in student problems: place value, basic operations on whole numbers, integers, rounding and estimation, decimals and percents.
EVALUATION: *Electronic Learning*, January, 1983; *Educational Technology*, February, 1983; *Courseware Report Card*, December 1982.

CONCEPT: Integers
LEVEL: Grades 1 to 9
SOFTWARE TITLE: Grand Prix
PUBLISHER: Random House
201 East 50th St.
New York, NY 10022
SUGGESTED PRICE: $175.00
HARDWARE: TRS-80
DESCRIPTION: Grand Prix is a drill and practice program set in the format of a race car game. The student is the driver, solving math problems to win the Grand Prix. Student options are available to choose levels of difficulty in the math problems and the driving course. Math topics available through this program include: place value, decimals and percents, integers, rounding and estimation, basic operations on whole numbers.
EVALUATION: *EPIE*, 1985.

CONCEPT: Integers
LEVEL: Grades Preschool to 4
SOFTWARE TITLE: Bumble Games
PUBLISHER: Learning Company
545 Middlefield Rd.
Menlo Park, CA 94125
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64; Atari
DESCRIPTION: Bumble Games is a series of six instructional games that teach children to plot numbers and find locations on a grid-like map. Bumble is a screen character who assists students in the self-paced games.
EVALUATION: *Curriculum Review*, August, 1983; *MicroSIFT*, May 1983.

CONCEPT: Integers
LEVEL: Grades 1 to 8
SOFTWARE TITLE: Math Sequences
PUBLISHER: Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St. Louis, MO 63132-0579
SUGGESTED PRICE: $450.00
HARDWARE: Apple II Series; Atari
DESCRIPTION: Math Sequences is a drill and practice package containing twelve content areas covered in most school math curricula. The lessons are self-paced and provide students with correction and feedback. Assignments and mastery levels can be determined by the teacher on a class or individual basis. Progress graphs can be made from student performance records. The content areas on the twelve diskettes include: Number Readiness, Addition, Subtraction, Multiplication, Division, Laws of Arithmetic, Integers, Fractions, Decimals, Percents, Measurement Formulas.
EVALUATION: *The Computing Teacher*, April, 1982; *MicroSIFT*, October, 1981; *EPIE*, 1985; *Educational Teachnology*, October, 1981.

CONCEPT: Integers
LEVEL: Grades Preschool to 3
SOFTWARE TITLE: Bumble Plot
PUBLISHER: Learning Company
545 Middlefield Rd.
Menlo Park, CA 94125
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Bumble Plot includes a series of five instructional games centered around a theme of locating robbers and treasures. Students use positive and negative numbers to move around on the graph and locate the treasures. This program builds on concepts introduced in Bumble Games and teaches users to plot their own numbers. Students learn to plot numbers to create and design pictures on the computer screen.
EVALUATION: *MicroSIFT*, May 1983; *Courseware Report Card*, December, 1982.

INTEGERS

CONCEPT: Integers
LEVEL: Grades 4 to 9
SOFTWARE TITLE: Battling Bugs/Concentration
PUBLISHER: Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St. Louis, MO 63132-0579
SUGGESTED PRICE: $32.95
HARDWARE: Apple II Series
DESCRIPTION: Battling Bugs and Concentration are two programs presented in a game format. Battling Bugs reinforces the concept of positive and negative numbers. In Concentration, students are to match equivalent fractions.

CONCEPT: Integers
LEVEL: Grades 4 to 12
SOFTWARE TITLE: Elementary Math Mixer
PUBLISHER: Control Data Publishing - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series
DESCRIPTION: Elementary Math Mixer is a drill and practice program recorded on two disks. The first disk includes the program Money, Money, Money in which students count, make change, add, and subtract money. The second disk, Games of Chance, reinforces skills in computation of whole numbers, decimals and integers.

CONCEPT: Money
LEVEL: Grades 2 to 6
SOFTWARE TITLE: Money
PUBLISHER: Gamco Industries
P.O. Box 310W23
Big Spring, TX 79721
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Money is an instructional program emphasizing computation skills involving money. Students work on recognizing coins, counting money, and figuring change. Accurate computation is rewarded with an adventure game called "Blackbeard's Ghost." This package provides the teacher with options to regulate the variety and number of problems presented in the lesson. Individual and class files can also be formulated and printed.
EVALUATION: *Arithmetic Teacher*, December, 1985.

CONCEPT: Money
LEVEL: Grades 4 to 12
SOFTWARE TITLE: Elementary Math Mixer
PUBLISHER: Control Data Publishing - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series
DESCRIPTION: Elementary Math Mixer is a drill and practice program recorded on two disks. The first disk includes the program Money, Money, Money in which students count, make change, add, and subtract problems on money. The second disk, Games of Chance, reinforces skills in skip counting, reading whole numbers, reading decimals, and computation of whole numbers, decimals, and integers.

MULTIPLICATION

CONCEPT:	Multiplication
LEVEL:	Grades 1 to 6
SOFTWARE TITLE:	Basic Number Facts
PUBLISHER:	Control Data Publishing - Plato P.O. Box 261127 San Diego, CA 92126
SUGGESTED PRICE:	$39.95
HARDWARE:	Apple IIe, II+; Atari 800; TI 99/4A; IBM PC
DESCRIPTION:	Basic Number Facts is a drill and practice program presented in four lessons through a game format, that resemble a car race. Students can choose to solve problems in addition subtraction, multiplication and division. Levels of difficulty increase as students master the operations. Teachers are offered a record keeping system.
EVALUATION:	*EPIE*, 1985; *MicroSIFT*, June, 1984.

CONCEPT:	Multiplication
LEVEL:	Grades 2 to 6
SOFTWARE TITLE:	Math Blaster
PUBLISHER:	Davidson and Associates 6069 Groveoak Place #12 Ranch Palos Verde, CA 90274
SUGGESTED PRICE:	$49.95
HARDWARE:	Apple II Series; IBM PC
DESCRIPTION:	Math Blaster is a drill and practice program using math facts with numbers up to twenty. Math problems are offered through four activities stressing skills in addition, subtraction, multiplication and division. Students have the option to choose problems from five levels of difficulty or to create their own problems and insert them into the program. Higher level math problems are used in the operation on decimals and fractions.
EVALUATION:	*Arithmetic Teacher*, March, 1985; *EPIE*, 1985; *InfoWorld*, July July 11, 1983.

CONCEPT:	Multiplication
LEVEL:	Grades 1 to 6
SOFTWARE TITLE:	Basic Math Facts Drill
PUBLISHER:	Random House 201 East 50th St. New York, NY 10022
SUGGESTED PRICE:	$66.00
HARDWARE:	Apple II Series
DESCRIPTION:	Basic Math Facts Drill is a drill and practice program that is presented in a lesson format with a game at the end of each lesson. Each lesson includes twenty exercises using basic math facts and provides correction and feedback. Scores appear at the end of each lesson and the program keeps track of facts not mastered.
EVALUATION:	*Courseware Report Card*, December, 1982.

CONCEPT: Multiplication
LEVEL: Grades K to 3
SOFTWARE TITLE: Fay: That Math Woman
PUBLISHER: Didatech
549-810 West Broadway
Vancouver, BC V524C9
SUGGESTED PRICE: $29.95
HARDWARE: Apple II Series
DESCRIPTION: Fay: That Math Woman is an instructional support program that helps students understand the basic math operations. Fay is a screen character who uses the number line to illustrate addition, subtraction, multiplication and division.

CONCEPT: Multiplication
LEVEL: Grades 3 to 6
SOFTWARE TITLE: Sum Ducks
PUBLISHER: Spinnaker Software
215 First St.
Cambridge, MA 02142
SUGGESTED PRICE: $34.95
HARDWARE: Apple II Series
DESCRIPTION: Sum Ducks is a group of games encouraging students to use skills in factoring, finding prime numbers. and creating multiples.

CONCEPT: Multiplication
LEVEL: Grades 3 to 6
SOFTWARE TITLE: Whole Numbers
PUBLISHER: Control Data Publishing - Plato
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $39.95
HARDWARE: Apple IIe/II+; Atari 800; TI 99/4A; IBM PC
DESCRIPTION: Whole Numbers is a drill and practice program presented in five lessons through a game format resembling pinball. Students compute answers to problems in addition, subtraction, multiplication, division and mixed operations. Student performances are recorded for the teacher.
EVALUATION: *EPIE*, 1985.

MULTIPLICATION

CONCEPT: Multiplication
LEVEL: Grades K to 6
SOFTWARE TITLE: Meteor Multiplication
PUBLISHER: Developmental Learning Materials
One DLM Park
Allen, TX 75002
SUGGESTED PRICE:
HARDWARE: Apple II Series; Commodore 64; IBM PC
DESCRIPTION: Meteor Multiplication is a drill and practice program stressing skills in multiplication facts. The program is presented in an arcade game format. The student is responsible for correctly answering multiplication problems and thereby saving a space station from a meteor attack. Meteor Multiplication is part of the Arcademic Math Skill Builders Series.
EVALUATION: *Arithmetic Teacher*, March, 1985; *Education Technology*, November, 1982; *Curriculum Review*, August, 1982.

CONCEPT: Multiplication
LEVEL: Grades 3 to 6
SOFTWARE TITLE: Dragon Mix
PUBLISHER: Developmental Learning Materials
One DLM Park
Allen, TX 75002
SUGGESTED PRICE: $44.00
HARDWARE: Apple II Series; Commodore 64; IBM PC
DESCRIPTION: Dragon Mix is a drill and practice program emphasizing multiplication and division facts. The problems are presented in a game format. Students are provided with the answers for self-correction. Dragon Mix is part of the Arcademic Skill Builders Series.
EVALUATION: *Arithmetic Teacher*, March, 1985; *EPIE*. 1985.

CONCEPT: Multiplication
LEVEL: Grades K to 12
SOFTWARE TITLE: Multiploy
PUBLISHER: MicroMedia Publishing
6 Arrow Rd.
Ramsey, NJ 07446
SUGGESTED PRICE: $24.95
HARDWARE: Apple II Series
DESCRIPTION: Multiploy is a drill and practice program presented in an arcade-game format. Students choose from three levels of difficulty in addition, subtraction, multiplication, and division problems. The object of the game is to quickly and accurately answer math problems. Incorrect responses will be shown at the end of each game. Student scores are collected for the teacher to evaluate performance.
EVALUATION: *EPIE*, 1985; *Electronic Learning*, March, 1983.

CONCEPT: Multiplication
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Space Math
PUBLISHER: Learning Well
200 South Service Rd.
Roslyn Heights, NY 11577
SUGGESTED PRICE: $49.95
HARDWARE: Apple II Series; IBM PC
DESCRIPTION: Space Math is a drill and practice program that uses a game format. Students compute math problems using addition, subtraction, multiplication, and division. Correct responses allow the student to participate in a space game.

CONCEPT: Multiplication
LEVEL: Grades 2 to 6
SOFTWARE TITLE: Prescriptive Math Drill
PUBLISHER: Hartley Courseware
123 Bridge Street, Box 419
Dimondale, MI 48821
SUGGESTED PRICE: $79.95
HARDWARE: Apple II, IIe
DESCRIPTION: Prescriptive Math Drill is a drill and practice program emphasizing addition, subtraction, multiplication and division. Program options allow the teacher to indicate the student's entry level, prescribe the level of difficulty and specify the mastery score needed to continue with the next drill.
EVALUATION: *SECTOR*, April, 1982; *MicroSIFT*, April 1983; *School Microware Review*, Winter, 1982.

CONCEPT: Multiplication
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Multiplication Brigade
PUBLISHER: Gamco Industries
P.O. Box 310W23
Big Spring, TX 79721
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64; TRS-80 III
DESCRIPTION: Multiplication Brigade is a drill and practice program that is presented in lesson format followed by a reward game. The teacher has a management system within the program to indicate the number, speed and level of difficulty of the problems, and to incorporate the reward game. By solving multiplication problems that appear in the windows of the burning building, students put out the fire in the building.

MULTIPLICATION

CONCEPT:	Multiplication
LEVEL:	Grades 3 to 6
SOFTWARE TITLE:	The Arithmetic Classroom: Multiplication with Whole Numbers
PUBLISHER:	Sterling Swift Publishing Company 7901 South IH-35 Austin, TX 78744
SUGGESTED PRICE:	$49.95
HARDWARE:	Apple II
DESCRIPTION:	The Arithmetic Classroom: Multiplication is an instructional program which includes six hierarchic lessons emphasizing multiplication computation using whole numbers. Each lesson includes an example of the level of multiplication problems, a practice section, and a mastery test over the skills stressed. In addition to the diskette, this software package includes student workbooks and record forms.
EVALUATION:	*Arithmetic Teacher*, October, 1984.

CONCEPT: Problem Solving
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Math Man
PUBLISHER: Scholastic Software
P.O. Box 7502
2931 E. McCarty St.
Jefferson City, MO 65102
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; IBM PC PCjr
DESCRIPTION: Students manipulate a construction worker on the screen by deciding which arithmetic operation should be used to arrive at a target number. Level of difficulty is increased as the student quickly and successfully arrives at a randomly generated number.

CONCEPT: Problem Solving
LEVEL: Grades K to 3
SOFTWARE TITLE: Introducing Logo to Primary Children
PUBLISHER: Houghton Mifflin
One Beacon St.
Boston, MA 02108
SUGGESTED PRICE: $74.97
HARDWARE: Apple II Series; Logo language disk needed.
DESCRIPTION: Logo is introduced in a sequence of four individual programs. Each program teaches the child more about the language and graphics of Logo.
EVALUATION: *Arithmetic Teacher*, January, 1985.

CONCEPT: Problem Solving
LEVEL: Grades 3 to Adult
SOFTWARE TITLE: Safari Search
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570
SUGGESTED PRICE: $59.00
HARDWARE: Apple II Series
DESCRIPTION: Safari Search is a simulation of jungle travel which entices students to decode clues to find mystery animals. A grid appears on the screen and clues are given in units for students to locate the animal. Clues range in levels of difficulty.
EVALUATION: *Computing Teacher*, March, 1986.

PROBLEM SOLVING

CONCEPT:	Problem Solving
LEVEL:	Grades Preschool to 6
SOFTWARE TITLE:	Odd One Out
PUBLISHER:	Sunburst Communications 39 Washington Ave. Pleasantville, NY 10570
SUGGESTED PRICE:	$49.00
HARDWARE:	Apple II Series
DESCRIPTION:	This program is divided into five problem solving games addressing specific skills and age levels. The games stress skills in classification, visual discrimination, counting, identifying operations and computing math problems.
EVALUATION:	*Arithmetic Teacher*, April, 1985; *EPIE*, 1985.

CONCEPT:	Problem Solving
LEVEL:	Grades K to 6
SOFTWARE TITLE:	Gertrude's Puzzles
PUBLISHER:	The Learning Company 545 Middlefield Rd. Menlo Park, CA 94025
SUGGESTED PRICE:	$44.95
HARDWARE:	Apple II Series
DESCRIPTION:	Gertrude's Puzzles is a learning game that encourages the use of reasoning skills through the solution of puzzles. Various levels of difficulty are available.
EVALUATION:	*EPIE*, 1985; *The Computing Teacher*, September, 1983; *Educational Technology*, August, 1983.

CONCEPT:	Problem Solving
LEVEL:	Preschool to Grade 4
SOFTWARE TITLE:	Gertrude's Secrets
PUBLISHER:	The Learning Company 545 Middlefield Rd. Menlo Park, CA 94025
SUGGESTED PRICE:	$44.95
HARDWARE:	Apple II Series
DESCRIPTION:	Gertrude's Secrets is a learning game that encourages logical thinking. Students participate in sorting and ordering shapes and colors.
EVALUATION:	*EPIE*, 1985; *The Computing Teacher*, May, 1983; *Courseware Report Card*, June, 1983.

CONCEPT: Problem Solving
LEVEL: Grades 3 to 6
SOFTWARE TITLE: The Fermi-Pico Bagels Logo Game: Developing Thinking Skills Using Words and Lists
PUBLISHER: Trillium Press
P.O. Box 921
Madison Square Station
New York, NY 10159
SUGGESTED PRICE: $19.95
HARDWARE: Apple II Series; IBM PC
DESCRIPTION: The Fermi-Pico Bagels Logo Game is a problem solving game similar to the game of Mastermind. In order to run this package the user needs to first load the Terrapin Logo program. Players use Logo procedures is this game. Codes are used to indicate the opponents locations.
EVALUATION: *Arithmetic Teacher*, March, 1986.

CONCEPT: Problem Solving
LEVEL: Grades 3 to 8
SOFTWARE TITLE: Puzzle Tanks
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
SUGGESTED PRICE: $59.00
HARDWARE: Apple II Series; TRS-80 I, II, III, IV
DESCRIPTION: Puzzle Tanks is a game which reinforces basic skills in addition, subtraction, multiplication, division, and builds problem solving strategies. Students choose from four levels of difficulty and solve the problems encountered in filling, moving and emptying tanks.

CONCEPT: Problem Solving
LEVEL: Grades 4 to Adult
SOFTWARE TITLE: The Factory
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
SUGGESTED PRICE: $59.00
HARDWARE: Apple II Series
DESCRIPTION: The Factory is a simulation of the activities of three machines: hole punching, striping, and rotating. Through the use of graphics and animation, students use problem solving strategies to reproduce figures like those shown on the machine assembly line. Students will have the option to choose various levels of difficulty of the figures presented.
EVALUATION: *Colorado Mathematics Teacher*, May, 1985; *EPIE*, 1985; *Classroom Computer Learning*, October, 1983; *Courseware Report Card*, June, 1983.

PROBLEM SOLVING

CONCEPT: Problem Solving
LEVEL: Grades 4 to Adult
SOFTWARE TITLE: The King's Rule
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
SUGGESTED PRICE: $59.00
HARDWARE: Apple II Series
DESCRIPTION: This software is presented in six levels of play in a game format. Students will work their way through a castle by recognizing number patterns and relationships.
EVALUATION: *EPIE*, 1985.

CONCEPT: Problem Solving
LEVEL: Grade 3 to Adult
SOFTWARE TITLE: Teasers by Tobbs
PUBLISHER: Sunburst Communications
39 Washington St.
Pleasantville, NY 10570
SUGGESTED PRICE: $59.00
HARDWARE: Apple II Series
DESCRIPTION: This package includes two programs that present students with a grid, and a series of addition and multiplication problems to solve. Students will need to think logically and perform mental computations. Six levels of difficulty are available in each program.
EVALUATION: *Mathematics Teacher*, February, 1984; *EPIE*, 1985; *Classroom Computer Learning*, January, 1984.

CONCEPT: Problem Solving
LEVEL: Grades 4 to Adult
SOFTWARE TITLE: Puzzle Tanks
PUBLISHER: Sunburst Communications
39 Washington St.
Pleasantville, NY 10570
SUGGESTED PRICE: $59.00
HARDWARE: Apple II Series; TRS-80 I,II,III,IV
DESCRIPTION: Puzzle Tanks is a game format which involves the student with thinking in numbers. Tanks are used to hold numbers and the students are required to juggle those numbers from tank to tank in order to arrive at a target number.

CONCEPT: Problem Solving
LEVEL: Grades 4 to Adult
SOFTWARE TITLE: Targets
PUBLISHER: Sunburst Communications
39 Washington St.
Pleasantville, NY 10570
SUGGESTED PRICE: $59.00
HARDWARE: Apple II Series
DESCRIPTION: Targets is presented in game format. Students are directed to combine numbers and choose basic math operations in order to arrive at a target number. Various levels of difficulty are available.

CONCEPT: Problem Solving
LEVEL: Grades 3 to 7
SOFTWARE TITLE: Logic Builders
PUBLISHER: Scholastic
730 Broadway
New York, NY 10031
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Logic Builders is an instructional game program that enhances the user's skills in problem solving, and visual and auditory discrimination. Three games use spiders to create webs for players to build, match or recall. One to three students can be involved in finding solutions to the problems posed.
EVALUATION: *Arithmetic Teacher*, March, 1986.

CONCEPT: Problem Solving
LEVEL: Grades 4 to 8
SOFTWARE TITLE: The Right Turn: Strategies in Problem Solving
PUBLISHER: Sunburst Communication
39 Washington Ave.
Pleasantville, NY 10570
SUGGESTED PRICE: $55.00
HARDWARE: Commodore 64
DESCRIPTION: Right Turn is a problem solving game that involves students in creating designs on a grid, and speculating how that design would change if it were to be rotated or flipped. Students use skills in matching, pattern recognition, and problem solving.
EVALUATION: *Arithmetic Teacher*, March, 1986.

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PROBLEM SOLVING

CONCEPT:	Problem Solving
LEVEL:	Grades 5 to Adult
SOFTWARE TITLE:	Magic Math
PUBLISHER:	Recreational Mathematical Software 129 Carol Dr. Clarks Summit, PA 18411
SUGGESTED PRICE:	$55.00
HARDWARE:	TRS-80, Models I, II, and VI
DESCRIPTION:	Magic Math includes thirty-six programs presented in a variety of instructional formats. The programs emphasize number patterns and curiosities in mathematics. Some of the programs include Pascal's Triangle, The Fibonacci Sequence, Hexapawn, and many more.
EVALUATION:	*Mathematics Teacher*, January, 1985.

CONCEPT:	Problem Solving
LEVEL:	Grades K to 6
SOFTWARE TITLE:	Jar Game/Chaos
PUBLISHER:	Milliken Publishing Company 1100 Research Blvd. P.O. Box 21579 St. Louis, MO 63132-0579
SUGGESTED PRICE:	$39.95
HARDWARE:	Apple II Series
DESCRIPTION:	Jar Game is an activity that gives students practice in solving problems in probability, and sequencing fractions. Chaos is an activity that emphasizes the concepts of shape recognition and spatial orientation.
EVALUATION:	*EPIE*, 1985.

CONCEPT:	Problem Solving
LEVEL:	Grades 4 to 8
SOFTWARE TITLE:	Wordmath
PUBLISHER:	Milliken Publishing Company 1100 Research Blvd. P.O. Box 21579 St. Louis, MO 63132-0579
SUGGESTED PRICE:	$200.00
HARDWARE:	Apple II Series
DESCRIPTION:	Wordmath is an instructional support program presented in a lesson format. Four disks provide lessons on problem solving strategies and ways to compute word problems. Each lesson has two levels of difficulty. A record keeping system is included in this program.

CONCEPT: Problem Solving
LEVEL: Grades K to 6
SOFTWARE TITLE: Problem Solving Memory: The First Step in Problem Solving
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
SUGGESTED PRICE: Programs 1-4, 4 disks @ $150.00; Programs 1-7, 7 disks @ $210.00; Programs 1-10, 10 disks @ $250.00
HARDWARE: Apple II Series
DESCRIPTION: Memory includes ten individual programs stressing problem solving skills in memory and recall. The programs are recorded on individual disks each with an activity or task that students will participate in.

1. Simon Says, K-6 - Sequencing skills are emphasized. Multiple players can be involved.
2. Teddy and Iggy, K-2 - Ordering of events are emphasized.
3. What's In a Frame?, K-6 - Remembering groups of objects in a timed activity.
4. Concentration, K-6 - Matching activities.
5. First Things First/Do This--Do That, 3-6 - Remembering a sequence.
6. Pick the Part, 3-6 - Remembering parts of a whole.
7. Was It There?/Was It Missing?, 3-6 - Identifying parts from a picture.
8. Regrouping, 4-6 - Regrouping skills using pictures and numbers.
9. Self-Testing, 5-6 - Students will build their own tests, focusing on remembering facts.
10. Memory Castle, 5-6 - Following and recalling directions.

PROBLEM SOLVING

CONCEPT: Problem Solving
LEVEL: Grades K to 6
SOFTWARE TITLE: Discrimination, Attributes and Rules: The Second Step in Problem Solving
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
SUGGESTED PRICE: Programs 1-3, 3 disks @ $150.00; Programs 1-6, 6 disks @ $190.00; Programs 1-8, 8 disks @ $225.00
HARDWARE: Apple II Series
DESCRIPTION: Discrimination, Attributes and Rules includes eight individual programs emphasizing problem solving skills of discrimination, attributes and rules. The programs are recorded on individual disks, each with an activity or task for students to participate in.

1. Teddy's Playground, K-2 - Practice looking for attributes.
2. Iggy's Gnees, K-2 - Discover attribute and build a rule.
3. Odd One Out, K-6 - Classify objects
4. Gnee Or Not Gnee, 3-6 - Students are given examples and asked to create a rule.
5. Flip Flop, 3-6 - Transformational geometry.
6. Make A Match, 3-6 - Students create a rule by giving examples.
7. What's the Rule, 5-6 - Rule discovery.
8. Ten Clues, 5-6 - Focus on critical attributes.

CONCEPT: Problem Solving
LEVEL: Grades 3 to 9
SOFTWARE TITLE: Logo Robot
PUBLISHER: Scholastic Software
P.O Box 7502
2931 East McCarty St.
Jefferson City, MO 65102
SUGGESTED PRICE: $24.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Logo Robot is an instructional support program that introduces students to Logo programming. Students move a Robot around on the screen by using specific commands and develop and use skills in deductive reasoning.

CONCEPT:	Rounding
LEVEL:	Grades 4 to 9
SOFTWARE TITLE:	Rounding
PUBLISHER:	Gamco Industries P.O. Box 310W23 Big Spring, TX 79721
SUGGESTED PRICE:	$39.95
HARDWARE:	Apple II Series; Commodore 64; TRS-80 III
DESCRIPTION:	Rounding is a drill and practice program presented in lesson format. Six lessons are available in this program for students to round whole numbers to tenths, hundredths, or thousandths place. Also included are lessons on rounding decimals to whole numbers, tenths, hundredths, or thousandths.

SUBTRACTION

CONCEPT:	Subtraction
LEVEL:	Grades 2 to 6
SOFTWARE TITLE:	Math Blaster
PUBLISHER:	Davidson and Associates 6069 Groveoak Place # 12 Rancho Palos Verde, CA 90274
SUGGESTED PRICE:	$49.95
HARDWARE:	Apple II; IBM PC
DESCRIPTION:	Math Blaster is a drill and practice program using math facts with numbers up to 20. The menu offers four learning activities for developing skills in addition, subtraction, multiplication and division. Five levels of difficulty are available for each basic operation, with higher levels using fractions and decimals. One option permits the user to create problems and include them in the program.
EVALUATION:	*Arithmetic Teacher*, March, 1985; *EPIE*, 1985; *InfoWorld*, July 11, 1983; *Courseware Report Card*, September, 1983.

CONCEPT:	Subtraction
LEVEL:	Grades 1 to 6
SOFTWARE TITLE:	Subtraction
PUBLISHER:	Micro Computer Workshops 103 Puritan Dr. Port Chester, NY 10573
SUGGESTED PRICE:	$24.95
HARDWARE:	Apple II Series
DESCRIPTION:	Subtraction randomly generates problems for students to practice. The program includes a way for students to pick a level of difficulty and keep track of their performance.

CONCEPT:	Subtraction
LEVEL:	Grades K to 3
SOFTWARE TITLE:	Minus Mission
PUBLISHER:	Developmental Learning Materials One DLM Park Allen, TX 75002
SUGGESTED PRICE:	$44.00
HARDWARE:	Apple II Series; Commodore 64; IBM Series
DESCRIPTION:	Minus Mission is a drill and practice program set in an arcade-game format. Correct responses will trigger a laser in time to stop the robot from being destroyed. The game can be controlled by variations of numbers and speed. At the conclusion of each game the student's performance record is displayed.
EVALUATION:	*Arithmetic Teacher*, March, 1985; *EPIE*, 1985; *Education Technology*, November. 1982.

CONCEPT: Subtraction
LEVEL: Grades 2 to 6
SOFTWARE TITLE: The Arithmetic Classroom: Games
PUBLISHER: Sterling Swift Publishing Company
7901 South IH-35
Austin, TX 78744
SUGGESTED PRICE: $49.95
HARDWARE: Apple II+, with paddle
DESCRIPTION: The Arithmetic Classroom: Games is a drill and practice program that provides three speed games using the basic operations on whole numbers and fractions.
EVALUATION: *Arithmetic Teacher*, October, 1984.

CONCEPT: Subtraction
LEVEL: Grades 2 to 6
SOFTWARE TITLE: Prescriptive Math Drill
PUBLISHER: Hartley Courseware
123 Bridge St., P.O. Box 419
Dimondale, MI 48821
SUGGESTED PRICE: $79.95
HARDWARE: Apple II, IIe
DESCRIPTION: Prescriptive Math Drill is a drill and practice program emphasizing the four basic operations in mathematics. The program allows the teacher to prescribe the entry level and level of difficulty, and specify the mastery score students need to achieve in order to continue with the next drill.
EVALUATION: *SECTOR*, April, 1982; *School Microware Review*, Winter, 1982; *MicroSIFT*, April, 1983.

CONCEPT: Subtraction
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Math Maze
PUBLISHER: Designware
185 Berry St, #3-158
San Francisco, CA 94107
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64; IBM Series
DESCRIPTION: Math Maze provides forty mazes with multiple skill levels. Students drill and practice basic math operations as they travel through each maze.

SUBTRACTION

CONCEPT: Subtraction
LEVEL: Grades 2 to 6
SOFTWARE TITLE: Math Run
PUBLISHER: Avant Garde Creations
P.O. Box 30160
Eugene, OR 97403
SUGGESTED PRICE: $34.95
HARDWARE: Apple Series
DESCRIPTION: Math Run is a drill and practice program emphasizing computation in addition, subtraction, multiplication and division. The program is presented in a game format resembling a race. The object of the game is to complete the computations correctly in the least amount of time.

CONCEPT: Subtraction
LEVEL: Grades 2 to 6
SOFTWARE TITLE: Basic Number Facts: Practice A Race to Improve Your Speed with Number Facts
PUBLISHER: Control Data Publishing Company
P.O. Box 261127
San Diego, CA 92126
SUGGESTED PRICE: $59.95
HARDWARE: Apple II Series
DESCRIPTION: Basic Number Facts: Practice is a drill and practice program emphasizing student accuracy and speed with the basic number facts. Students become race car drivers, choose which number facts they will practice, and then race around a track trying to improve their score. Scores can be viewed at the completion of each race.
EVALUATION: *EPIE*, 1985; *MicroSIFT*, June, 1984.

CONCEPT: Subtraction
LEVEL: Grades 4 to 6
SOFTWARE TITLE: Hey Taxi!
PUBLISHER: Milton Bradley Company
443 Shaker Rd.
East Longmeadow, MA 01028
SUGGESTED PRICE: $39.00
HARDWARE: Apple II Series
DESCRIPTION: Hey Taxi! is a simulation-game of driving a taxi. Students drill and practice basic mathematic facts through the calculation of fares and expenses they encounter on their shift as a taxi driver.
EVALUATION: *Arithmetic Teacher*, February, 1985.

CONCEPT: Subtraction
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Challenge Math
PUBLISHER: Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570-9971
SUGGESTED PRICE: $55.00
HARDWARE: Apple II Series
DESCRIPTION: Challenge Math is a drill and practice program presented in three game formats. The program provides various levels of difficulty for practicing basic math operations on whole numbers, decimals and fractions.
EVALUATION: *Arithmetic Teacher*, September, 1984.

CONCEPT: Subtraction
LEVEL: Grades 1 to 4
SOFTWARE TITLE: Stickybear Math
PUBLISHER: XEROX
245 Longhill Rd.
Middletown, CT 06457
SUGGESTED PRICE: $39.95
HARDWARE: Apple II Series; Commodore 64
DESCRIPTION: Stickybear Math is an instructional support program for the concepts of addition and subtraction. The program introduces a bear character that helps children to understand and compute problems in these skill areas. Multiple levels of difficulty are available. Individual student progress can be monitored and stored for the teacher.
EVALUATION: *EPIE*, 1985; *Classroom Computer Learning*, January, 1984.

CONCEPT: Subtraction
LEVEL: Grades 1 to 6
SOFTWARE TITLE: Basic Math Facts Drill
PUBLISHER: Random House
201 East 50th St.
New York, NY 10022
SUGGESTED PRICE: $66.00
HARDWARE: Apple II Series
DESCRIPTION: Basic Math Facts Drill is a drill and practice program emphasizing basic math facts. The program is presented in lesson format with a game at the end of each lesson. Each lesson includes twenty exercises using basic math facts. Immediate correction is provided for the student. Scores appear at the end of each lesson and the program keeps track of facts not mastered.
EVALUATION: *Courseware Report Card*, December, 1982.

SUBTRACTION

CONCEPT:	Subtraction
LEVEL:	Grades 1 to 6
SOFTWARE TITLE:	Space Math
PUBLISHER:	Learning Well 200 South Service Rd. Roslyn Heights, NY 11577
SUGGESTED PRICE:	$49.95
HARDWARE:	Apple II Series; IBM PC
DESCRIPTION:	Space Math is a drill and practice program that uses a game format. Students compute math problems using addition, subtraction, multiplication, and division. Correct responses allow the student to participate in a space game.

CONCEPT:	Subtraction
LEVEL:	Grades K to 3
SOFTWARE TITLE:	Fay: That Math Woman
PUBLISHER:	Didatech 549-810 West Broadway Vancouver, BC V524C9
SUGGESTED PRICE:	$29.95
HARDWARE:	Apple II Series
DESCRIPTION:	Fay: That Math Woman is an instructional support program that assists students in understanding math operations. Fay is a screen character who uses the number line to illustrate addition, subtraction, multiplication and division.

CONCEPT:	Subtraction
LEVEL:	Grades 1 to 6
SOFTWARE TITLE:	Subtraction Defenders
PUBLISHER:	Gamco Industries P.O. Box 310W23 Big Spring, TX 79721
SUGGESTED PRICE:	$39.95
HARDWARE:	Apple II Series; Commodore 64; TRS-80 III
DESCRIPTION:	Subtraction Defenders is a drill and practice program that is presented in lesson format followed by a reward game. The teacher has a management system within the program to indicate the number, speed, and level of difficulty of the problems, and to activate or deactivate the arcade game. In the reward game, students must defend a castle wall from cannon ball fire by solving subtraction problems accurately.

CONCEPT:	Subtraction
LEVEL:	Grades K to 12
SOFTWARE TITLE:	Multiploy
PUBLISHER:	MicroMedia Publishing 6 Arrow Rd. Ramsey, NJ 07446
SUGGESTED PRICE:	$24.95
HARDWARE:	Apple II Series
DESCRIPTION:	Multiploy is a drill and practice program presented in an arcade-game format. Students choose problems from three levels of difficulty in addition, subtraction, multiplication, and division. The object of the game is to solve problems presented by the computer as quickly and accurately as possible, before a space ship blows up a target. Student scores and incorrect responses are shown at the end of each game. Scores can be recorded for teacher evaluation.
EVALUATION:	*EPIE*, 1985; *Electronic Learning*, March, 1983; *Educational Learning*, September, 1983.

EVALUATING SOFTWARE FOR LEARNING OUTCOMES

John B. Cooney

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EVALUATING SOFTWARE FOR LEARNING OUTCOMES

With a growing abundance of educational software, teachers face difficult selection decisions. Often, their choices are made under the constraints of limited funds for computer materials and tight classroom schedules. In these circumstances, teachers seek the educational software most likely to produce **positive learning outcomes.**

Innumerable "software evaluation" systems have emerged to help teachers select software. Unfortunately, nearly all software evaluation systems are heavily weighted on computer-related dimensions such as error-handling, aesthetic considerations, such as the quality of screen displays, and content related issues of scope, sequence, and accuracy. Although important, these characteristics do not address the essential question: **Is the software's design consistent with our knowledge of how students learn?** We contend that an adequate software evaluation model must arise from a clear perspective of the student as a learner.

The text material of this chapter leads to software evaluation questions and a sample software evaluation form. It can serve as a guide to identifying software likely to produce positive learning outcomes. Using this approach does not exclude using additional software evaluation procedures that emphasize computer and curriculum related issues. However, we suggest that if a particular software does not meet our standards of probable learning effectiveness, it is unlikely to prove satisfactory in everyday teaching situations.

HUMAN COGNITION

Over the past decade, research on human cognition has revealed new insights into the mental processes involved in learning, remembering, reasoning, and problem solving. These findings also have implications for the design and evaluation of educational software. An overview of the components, functions and limitations of the human cognitive system provides a framework for understanding why some educational software that "looks good" fails to produce positive learning outcomes.

Noted educational psychologist Robert M. Gagne (1984) identified five categories of learned capabilities involved in complex human performance:

* verbal knowledge
* intellectual skills
* cognitive strategies
* motor skills
* attitudes

These five capabilities are distinguished because each requires its own unique set of **external conditions** such as identifying goals, determining prerequisite knowledge and providing corrective feedback. And acquiring each capability is also contingent on the presence of a unique set of **internal conditions** in a learner: prerequisite verbal knowledge, intellectual skills, motor skills, and attitudes. Therefore, an analysis of the internal and external conditions necessary for acquiring a targeted skill must be part of educational software evaluation.

What are the basic elements of a human cognitive system? Contemporary theory suggests that, at the very least, the model of a human cognitive system must be capable of describing: a) the reception of sensory information; b) how information is represented in memory; c) the different states of information (aware vs. unaware); d) processes related to learning, remembering and thinking; and, e) the generation of overt behavior (Anderson, 1983; Bower, 1975). A model depicting these elements, as they may be affected through the interaction with a computer system, is presented in Figure 1. Arrows in the diagram represent the flow of information from a computer's screen through the various stages of cognitive processing. A careful study of this model and the descriptions of it's components will promote a better understanding of the conditions necessary to achieve a particular learning outcome.

Components of a Sensory System

What is the chain of events involved in a learner's cognitive response to computer produced stimuli? Verbal, auditory, and visual-spatial information from a computer stimulates the learner's sense receptors. In turn, these sense receptors transform the information into neural codes. Neural codes are then preserved, or "stored," briefly, usually a few hundredths of a second, in the learner's short term sensory register (Sperling, 1960). In this brief interval of time, information is preserved virtually exact. However, human attention is limited. Unless a student continuously attends to a computer display, sensory information is quickly lost. Sensory information which does not continue to receive attention "decays," or vacates the sensory register.

It is useful to think of attention as a filter which restricts the amount of information that can make contact with the long-term memory system. Note in Figure 1 that only a few elements of a computer display stored in the sensory register (represented by the arrows) is passed through this attention filter.

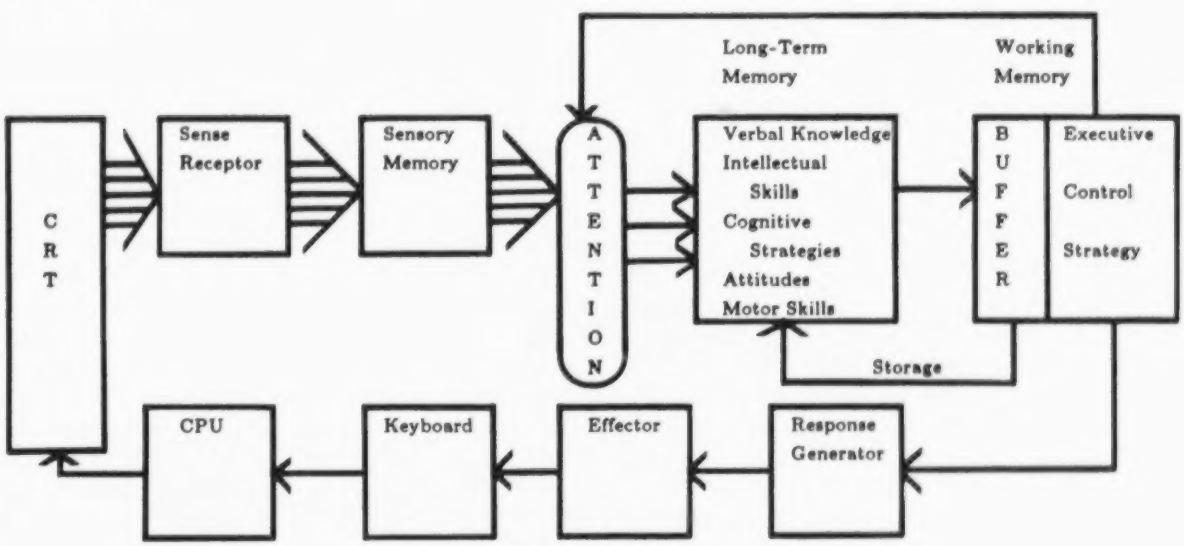

Figure 1

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Long-Term Memory

Within a few seconds, sensory information receiving continued attention activates knowledge in long-term memory. Information stored in long-term memory consists of attitudes, beliefs, sequences of motor skills, strategies for learning and problem solving, intellectual skills, and verbal knowledge.

A consistent finding from research on long-term memory for text, pictures, conversations or other events, is that people do not remember exact details. Rather, it appears that our experiences are transformed into an abstract memory code (proposition) that preserves the meaning of an experience. Although controversy remains over exactly how knowledge is stored in long-term memory, current research suggests that it is organized hierarchically. It may be helpful to think about a taxonomy with superordinate and subordinate concepts that are linked together to form a network. Reading a word results in the activation of its long-term memory code and the spreading of activation to related concepts. For example, comprehension of the sentence "mammals are warm-blooded" depends on the activation of information (propositions) related to mammals (e.g., live birth, lungs), specific instances of mammals (e.g., dog, whale, elephant) and being warm-blooded (consistent body temperature). Other knowledge (e.g., intellectual skills, and cognitive strategies) have different representations in long-term memory that will be discussed later in this section.

Working Memory

Verbal knowledge, intellectual skills and cognitive strategies, activated by the information displayed on the computer monitor, become part of the students' working memory system. A useful analogy is to think of working memory as a workbench where conscious mental processing is carried out (Klatzky, 1975). Working memory is a complex and powerful memory system. Note in Figure 1 that working memory consists of a short-term memory buffer capable of holding a small amount of verbal information called "chunks," visual-spatial information and a central executive (Baddeley and Hitch, 1974).

Simon (1980) defines a chunk as any perceptual configuration of visual or auditory stimuli that is familiar and recognizable. Examples of chunks include words, phrases and rules. On the average, the short-term memory buffer can maintain about four chunks of information in an active (conscious) state. However, chunks may be very large and complex. The central executive, governed by the learner's goals and motives, is responsible for selective attention and a variety of other control processes which: a) modify and transform information in the short-term memory buffer; b) store information in long-term memory; and, c) retrieve information from long-term memory.

Storage

First, examine the role of selective attention depicted in Figure 1. Note the arrow that connects the working memory system with the process of attention. Depending on features of the computer display, goals and motives, students will selectively attend to certain information on the display at the expense of other information. Adding (storing) one new chunk of information to long-term memory requires about eight seconds of attention while several minutes of attention may be required to add

a complex chunk of information to long-term memory, if the elementary chunks have to be acquired (stored in long-term memory) at the same time (Simon, 1980).

Storage of information in long-term memory can be hastened somewhat by invoking other control processes such as rehearsal, elaboration and organizational strategies. Rehearsal may be thought of as the subvocal recitation of chunks in the short-term memory buffer. Reciting a phone number until it has been dialed, mentally reciting a short list of items needed for the evening meal on the way to the grocery store or the answer to a question asked by a teacher are examples of rehearsal. Interruption of the rehearsal cycle (e.g., a busy signal, a near accident on the way to the store, or a student laughing in the classroom) usually results in the loss of the information from short-term memory. To reactivate information, one must search long-term memory for the phone number, recipe or question. If retrieval failure occurs, we must return to external sources such as the telephone directory, recipe book, or the teacher. Although rehearsal promotes the storage of information in long-term memory, there are more efficient methods.

Adding new chunks of information to long-term memory is facilitated through the control process of elaboration. Elaboration involves the retrieval from long-term memory of additional information that is related to the new chunks of information. Noting similarities and dissimilarities of new information in relation to one's existing knowledge base contributes to the meaning and memorability of new information. Techniques that involve the construction of visual imagery are also considered examples of elaboration strategies. Examples of visual imagery are discussed later in this section. Similarly, organizational strategies consist of a conscious effort to label and categorize the contents of short-term memory. When properly activated, the control processes of rehearsal, elaboration and organization can result in more rapid acquisition and storage of new information as well as more efficient retrieval.

Retrieval

When the short-term memory buffer contains a question proposition, plans for guiding a search of long-term memory are retrieved, or activated, in the working memory system. Retrieval strategies typically involve a systematic plan for selecting cues from questions which are then used to activate relevant knowledge structures in long-term memory. In addition, students use decision rules to determine whether information activated will be useful for answering a question. If a student has used elaboration or organization strategies for storing information, the cues will make quick contact with relevant information. If a question states a problem to be solved, plans for solving the problem are assembled in working memory under the control monitor in much the same way. Each of these processes are described in greater detail later in this section.

Response Generation and Performance

Plans for achieving a goal are transmitted to a structure called a **response generator.** The response generator selects muscle groups to respond to a goal and perform the necessary sequence of movements. Subsequently, these messages are transmitted to **effectors,** resulting in overt action. In Figure 1, overt actions consist of pressing a key or sequence of keys on a computer's keyboard. Student actions are processed by the instructional program which modifies the information on the monitor and the information processing cycle begins again.

CATEGORIES OF LEARNING OUTCOMES

Verbal Knowledge

Verbal knowledge represents much of what students are expected to learn in school. Verbal knowledge is a fundamental building block for more complex forms of learning. However, the meaning of words is but a small fraction of the verbal knowledge that students are expected to learn. **Discourse** is a complex form of verbal knowledge. Examples of discourse are the pledge of allegiance, national anthem, Bill of Rights, or a poem. Often, students are asked to memorize discourse in verbatim form. However, Gagne warns that verbatim recall of discourse does not guarantee that students have extracted meaning.

People rarely store verbal knowledge verbatim. Verbal knowledge is stored in long-term memory as a collection of **propositions**. A proposition is the smallest unit of knowledge that can stand as a separate assertion (Anderson, 1984). A proposition can be represented as a list consisting of a relational term (verb, adjectives, predicate) and arguments (noun). Relational terms provide connections among the arguments. The general form of a proposition is:

(relation, argument 1, argument 2)

Consider the following statements: "The capital of Colorado is Denver" and "2+3=5." Each statement may be expressed in the following propositional notation:

(is capital of, Denver, Colorado)
(is 5, 2,+3)

Evidence of this underlying structure is provided by the finding that students have difficulty remembering whether they have seen the sentences: "Denver is the capital of Colorado" or "The Capital of Colorado is Denver." Nevertheless they have learned the capital of Colorado. The point is that **memory for verbal information is reconstructive.**

Are propositions stored as a collection of unrelated facts? No, propositions are encoded into long-term memory as organized networks. Depending on instruction and the students' organizational strategies, the associative network of states and capitals may be organized according to geographic region, the alphabet, or order of statehood. Likewise, number facts may be organized by families or in a two dimensional table. Not everyone stores propositions exactly the same.

Working memory extracts propositions from discourse and assembles them to derive meaning from a message. Computer displays containing numerous propositions increase working memory demands and decrease comprehension. Therefore, effective educational software limits the amount of information and propositions presented on a single screen display.

Internal Prerequisites to Verbal Knowledge

Evaluation of software designed to teach verbal knowledge must begin by identifying prerequisite internal conditions of knowledge and skills. Of the two sited propositions above, an evaluator might state that a software's effectiveness depends on students

having previously learned concepts of state, capital, numerosity, magnitude, and combination. Also, students must know the linguistic rules underlying comprehension. A learner must possess an equal or higher reading level than required by the computer lesson or frustration will impede acquisition of verbal knowledge.

External Prerequisites to Verbal Knowledge

After identifying necessary internal conditions, an evaluator should identify external prerequisites. First, does the software inform the learner of the lesson's goals and objectives? Second, does the software pretest, activate or teach the internal prerequisites? Other factors having a pronounced effect on verbal knowledge acquisition include:

Selective Repetition with Feedback

Recall and recognition of verbal knowledge improves through repetition. However, students become bored with software that continually repeat well-learned information. Therefore, software that monitors student performance and **presents unlearned items** offers a greater challenge while maximizing learning (Chant & Atkinson, 1978).

Encoding Context

The learning context profoundly affects a students' ability to retrieve information from long-term memory (Bower, 1972; Gartman & Johnson, 1972). Programs presenting verbal information in varied contexts establish more retrieval cues for recalling information.

Organizational Strategies

Teaching strategies for organizing verbal information improves recall by providing a systematic method of searching long-term memory (Bower, Clark, Lesgold, & Winzenz, 1969). Therefore, an evaluator should ask, "Does the software make explicit an organizational strategy for learning and remembering?"

Mnemonic Strategies

Persons demonstrating exceptional memory performance use techniques that make novel information meaningful. One powerful technique, the keyword method, uses imagery to link new information to the learner's existing knowledge base. This technique has been used effectively in learning a second language vocabulary, expanding native language vocabulary, and in learning scientific classification schemes. Even learning disabled students benefit from using mnemonic techniques (Mastropieri, Scruggs, & Levin, 1985).

Evaluation Questions for Verbal Knowledge

* Does the software teach the meaning of concepts as opposed to verbatim learning?

* Does the software assess prerequisite knowledge and skills?

* Does the software teach prerequisite knowledge and skills?

* Does the software link new concepts to existing knowledge?

* Does the software limit the amount of information presented on a single screen?

* Does the software monitor student performance to provide selective repetition and feedback?

* Does the software provide varied contexts for the encoding and retrieval of information?

* Does the software help students tie new information to existing information?

Intellectual Skills

Intellectual skills differ from verbal knowledge. Intellectual skills refer to "knowing how," as opposed to "knowing that" (Gagne, 1985). Intellectual skills, sometimes termed procedural knowledge or production systems, underlay the basic skills of reading, writing, and mathematics. These "basic skills" in turn provide essential procedures for learning about other subjects such as music, social studies or art.

Generally, intellectual skills involve symbol manipulation such as calculating, classifying, distinguishing and transforming symbol systems. Intellectual skills range from simple (calculating a sum of two numbers or forming plurals) to complex (using metaphors and analogies in writing, or proving a geometric theorem).

A basic intellectual skill is represented in long-term memory as a production system consisting of rules. Most human behavior is rule governed even if by the wrong rule. This does not mean that an individual can always state the rule used to accomplish a goal. Still, their behavior appears to be rule governed. Young children and many adults cannot state the rules of grammar, yet their language conforms to linguistic rules. For example, when children are asked to form the plural of the nonsense word "wug," a typical reply would be "wugs." This response conforms to the rule: "If the goal is to form a plural noun, and the noun ends in a hard consonant, then generate noun + s."

Intellectual skills are stored in long-term memory as production systems. Production systems are organized as rules consisting of goals, conditions and action propositions. The general form of a production system can be represented as follows:

IF the goal is to achieve X and condition Y is true
THEN perform action Z

Consider the production system for achieving subject-verb agreement:

IF the goal is to achieve subject-verb agreement and the subject is singular
THEN generate (retrieve) a singular verb

Changes in production systems occur as a child matures and gains experience in symbol manipulation. For example, in learning to perform single digit addition, children use counting strategies. Older children and adults typically retrieve the answer from memory (Ashcraft, 1982). Given the problem 2+3= ?, differences in the production systems of children and adults can be represented as follows:

Child:

IF the goal is to find a sum and the two addends are 2 and 3
THEN set a counter equal to the largest addend (3) and increment the counter 2 times

Adult:

IF the goal is to find a sum and the two addends are 2 and 3
THEN search memory to retrieve the answer

Adults typically retain a counting production system and revert to it when memory retrieval fails. Elapsed time in problem solving and the types of errors that children and adults make support this interpretation of simple mental addition.

Acquiring an intellectual skill consists of three stages: cognitive stage, associative stage, and autonomous stage (Anderson, 1983; Fitts & Posner, 1967). Acquiring a skill begins with developing verbal knowledge (cognitive stage) about the steps involved in the skill. That is, students store facts related to a skill in long-term memory by rehearsing the fact while they perform the skill.

When learning to strum a melody's chord progression on a guitar, students must first learn to position their fingers on the fingerboard while striking the strings to produce a chord. Even after students have learned to produce chords in the correct order, in the cognitive stage their knowledge is inadequate for skilled performance. Students must also learn to produce the chords in tempo.

Having established the relevant verbal knowledge in long-term memory, transition to the associative stage begins. With continuing feedback , learners begin to detect and eliminate errors in their understanding of how to perform the skill (play the guitar chords). Associations between components of a skill are strengthened.

Now a learner's knowledge is transformed into a procedural form, a **production system.** Transition to the autonomous stage is characterized by an increase in performance speed and accuracy and the disappearance of verbal mediation during performance. A learner no longer thinks about the required steps. He or she may even lose the ability to articulate the verbal knowledge related to the skill.

Improvements in the performance of an intellectual skill during the autonomous stage occur in smaller and smaller increments. Diminishing returns are associated with practice. There appear to be no cognitive limitations on the speed of performing an intellectual skill during the autonomous stage. Any limitations are imposed by involved musculature or learner motivation.

Internal Prerequisites for Acquiring Intellectual Skills

Evaluating software designed to teach intellectual skills begins with identifying the internal prerequisites for successful learning (e.g., knowledge and skills). An answer to the question, "What verbal knowledge and subordinate skills are learners presumed to possess?", must be obtained.

External Prerequisites to Intellectual Skills

Gagne (1985) provided a concise summary of the external conditions or "events of instruction" necessary for acquiring intellectual skills. An overview of these conditions and their implications for software evaluation follows.

Cognitive Stage

Does instruction begin with a statement of the goals and performance expected when learning is complete? Too often instructional software simply informs learners that they will learn about a subject without stating the conditions or desired outcome. For example, students should be informed that they will learn a two-column procedure for proving two triangles congruent using the side-side-side and side-angle-side postulates. The statement "you will learn geometric proofs" is inadequate.

Does instruction pretest, activate, or teach the components, subordinate verbal knowledge and procedural skills, comprising the intellectual skill? One cannot assume that students possess appropriate internal conditions or that students will recall information on their own.

Associative Stage

Does the software use explicit cues that lead students to associate the components of the skill in the proper order? There should be no mystery shrouding the steps leading to the successful performance of the skill.

Does the instructional software require the learner to demonstrate concrete instances of the rule or procedure? Does the software provide feedback on student understanding of a skill? Ideally, the software should diagnose which skill component is in error. However, here lies a major stumbling block to effective computer-based instruction. Programming computers to provide this kind of feedback has been extremely difficult and found to require tremendous amounts of computing power. The reader is referred to Sleeman and Brown (1982).

Does the software require students to make an explicit verbal statement of the rules underlying a skill? Although a student's ability to state a rule may diminish during the autonomous stage, it is usually helpful for a student to be able to verbalize a rule.

Autonomous Stage

Does the instructional software involve spaced, or distributed, practice? Performance decrements often result from instruction that requires massed,

intense practice. For example, spaced practice resulted in superior retention of algebraic rules in contrast to massed practice (Gay, 1973). Another aspect of practice that affects skill acquisition is part vs. whole learning. Does the software attempt to teach the skill in parts or in its entirety? Again, basic research has demonstrated that it is better to teach the entire sequence than subsections of the sequence (Schulz and Gorgein, 1976).

Does the software provide the student with varied contexts to demonstrate the application of the rule? As with verbal knowledge, varied contexts facilitate retrieval and transfer of learning.

Evaluation Questions For Intellectual Skills

* Does the software pretest or teach prerequisite verbal knowledge?
* Does the software describe goals in detail?
* Does the software describe the performance level to be achieved?
* Does the software provide explicit cues to help students correctly sequence component skills?
* Does the software require students to provide concrete examples of a rule or procedure?
* Does the software provide feedback to students, enabling them to check for understanding?
* Can the software diagnose student errors?
* Does the software require students to verbalize their understanding of knowledge or a skill?
* Does the software teach the whole skill as opposed to separate component parts?
* Does the software provide for student practice of the whole skill?
* Does the software provide varied contexts in which students are required to apply a rule?

Cognitive Strategies

Cognitive strategies refer to skills for managing attention, learning, remembering, reasoning and problem solving. They involve knowledge about one's cognitive functions and limitations. In contrast to "knowing that" or "knowing how," cognitive strategies are skills related to "learning how to learn." They support self-instruction and independent learning. In the cognitive model, cognitive strategies are executive control processes carried out in working memory.

Of all learning outcomes, the least is known of processes leading to the acquisition of

cognitive strategies and their transfer to novel situations and problems. Nevertheless, the software market is rife with software that claim to develop cognitive strategies. One example involving the use of computers to teach children problem solving and higher order cognitive strategies is the LOGO language (Papert, 1980). Few educators or computer scientists dispute LOGO's superiority as a programming language. There is skepticism, however, about the claims of learning outcomes resulting from learning how to program in LOGO. Most evidence from well-controlled studies fails to support claims that learning LOGO enhances problem solving skills. When asked to read a LOGO program and describe the function of each line, children could not demonstrate that they understood the concepts of sequentiality, recursion, or conditional statements, despite having used them in their own programs. Furthermore, students who had learned to program in LOGO did not demonstrate better planning skills than students who did not learn to program in LOGO (see Tetenbaum & Mulkeen, 1984 for further discussion).

One purpose for noting LOGO's inadequacies as a means for teaching general problem solving skills is to illustrate the difficulty of teaching general problem solving skills, not to denigrate LOGO. There are many examples of other procedures for directly teaching problem solving that have had little success (Greeno, 1980; Newell, 1980). What has become clear from the research is that problem solving is far too complex to hope for identifying a small set of underlying skills.

Existing data also suggests that problem solving cannot be separated from its content domain. However, before a detailed discussion of the issues and criteria for judging problem solving software, a few of the more cognitive strategies will be addressed. More is known about teaching cognitive strategies related to attention, encoding for storage in long-term memory, and retrieval from long-term memory, than is known about problem solving.

Like any other skill, learning to attend to important aspects of discourse can be taught. A promising technique involves using adjunctive questions inserted in the text (Rothkopf, 1970). Also, teaching students about the structure of text has been found to improve their attention to and their comprehension of important information.

Strategies for encoding, storing, and retrieving information in long-term memory distinguish between "good" and "poor" learners (Rohwer, 1975). Typically, capable learners are aware that if they want to remember a new concept they must do something with the information (Brown, 1978; Flavell, 1976). At the lowest level, this would involve rehearsing the information they wish to retain. However, there are more powerful strategies. Some of these strategies involve elaborating a new concept by relating it to something previously established in memory. Similarly, organizing and categorizing new information is tantamount to developing a plan for retrieving the information later. In other words students learn to use the category label as a retrieval cue. Students may be taught these procedures through the insertion of prompts in the instructional software which require students to engage in a desired type of processing. Again, practice in varied contexts is an instructional component.

A more complex strategy involves using imagery. Information rich in imagery is remembered better than information low in imagery (Paivio, 1971). However, young children have difficulty generating their own imagery for new concepts. An example of this technique is the application of the keyword method for teaching mineral classification, involving hardness (Moh's scale), color, and use. First, students were

taught rhyming pegwords for the numbers 1 through 10 to represent the hardness scale (1=bun, 2=shoe, 3=tree, etc.). Then keywords that rhymed with some aspect of the mineral (e.g., pie for pyrite) were taught. For each mineral, an interactive image was developed containing the pegwords (hardness), keywords (rhyming with the mineral), color, and an object describing its use.

For example, the interactive image for pyrite contained a picture of a yellow pie (keyword and color attribute) supported by sticks (pegword for six on the hardness scale) with a bottle of acid (use) being poured onto the pie. This mnemonic technique was superior (94.8% recall) to either a free-study condition (76.7%) where students used their own strategies or a direct instruction procedure (63.5%) where students received drill and practice on recalling the items and their attributes (Mastropieri, Scruggs, McLoone & Levin, 1985). Similar results occurred in foreign language and native language vocabulary acquisition. Finally, learners can be taught to develop their own visual images by demonstrating the technique. With younger children, software should provide interactive images. For older children and adults, it is better if the software requires the student to generate the interactive image on their own.

Now it is time to revisit issues in teaching problem solving skills. Earlier, the difficulty of separating a problem solving strategy from its content domain (e.g., mathematics) was noted. A detailed description of the problem solving strategies in various content domains would require several chapters if not several volumes. Therefore, only fundamental knowledge about problem solving will be described to derive some general criteria for software evaluation. Readers interested in pursuing this research should consult Mayer (1985) for a discussion of problem solving in mathematics, Chi et al., (1981) for problems solving strategies in physics, and Anderson, Farrell & Saunders (1984), for a comparison of expert and novice problem solving strategies in the development of computer software.

Problem solving behavior is goal directed. The most comprehensive analysis of problem solving was developed by Newell & Simon (1972). In their analysis, problem solving is conceptualized as the process of defining the problem space or state and then searching the problem state for a sequence of actions (operators) that transform the problem from the initial state to the goal state. To illustrate, consider the following algebraic word problem:

> Write an equation to represent the following relationship:
>
> There are twice as many male students on campus as female students. Let M stand for the number of males and F the number of females.

Developing an accurate representation (defining the problem state) of the problem is essential. The stated goal is to write an equation, not solve an equation. If students define the problem state as finding the number of males or females, students will probably decide that the problem cannot be solved and give up. However, if students define the problem state according to the goal provided, searching the problem state for a solution can begin.

Teaching students how to develop an accurate representation of the problem state is among the most difficult and neglected steps in education (Simon, 1980). Many of the errors students make in solving problems involve errors in the translation of a problem into a form that can be solved. For the problem above, it would be common

for college students to write the equation as: 2M = F. If students were given the number of females and asked to calculate the number of males they would probably realize that they had made an error in writing the equation. The correct representation is M=2F or 1/2 M=F.

As problems become more complex, people often adopt general strategies in an attempt to find a solution. These general strategies are called heuristics. In contrast to rules or algorithms, which always produce the desired outcome, heuristics do not guarantee a solution. Heuristics are strategies that problem solvers use to guide their search of the problem space. A few of the more well known and successful heuristics are described below (Anderson, 1985; Wickelgren, 1974). Educational software should be carefully examined for these features before any claim is made that the software teaches students to become better problem solvers.

1. Difference-Reduction Method: Does the instructional software require students to set sub-goals that reduce differences between an initial problem state and the goal state?

2. Means-End Analysis: Does the instructional software lead students to: a) create sub-goals by defining the problem state as a collection of differences between the initial state and the goal state, and b) eliminate the most important difference first?

3. Working Backward: Does the instructional software demonstrate how a problem can be decomposed into an hierarchical set of sub-goals, and how solving the sub-goals at the bottom of the hierarchy can imply a solution to a problem.

4. Problem Solving by Analogy: Does the instructional software present the solution of a similar problem as a guide to finding the solution of the problem at hand?

5. Contradiction: Does the instructional software emphasize identifying contradictions proving the goal cannot be achieved from the information given?

Although these guidelines for evaluating "problem solving" software are general, they should be useful for determining if the software will be successful in teaching problem solving skills. In using these guidelines, remember that problem solving strategies must be taught in the context of a content domain.

Evaluation Questions for Cognitive Skills

* Does the software pretest for or teach prerequisite verbal knowledge?

* Does the software require students to define a problem?

* Does the software direct students toward a precise goal?

* Does the software require students to set sub-goals?

* Does the software require students to decompose a problem into a hierarchical form and solve from the bottom up?

* Does the software provide a similar problem as a guide?

* Does the instructional software emphasize identifying contradictions?

* Does the software provide a context for the problem?

CONCLUSIONS

Research on cognitive processes underlying human abilities has produced extensive knowledge about learning, remembering, reasoning, and problem solving. Although much remains to be learned the knowledge that has been gained can be put to immediate use in designing and evaluating instructional materials and practices. The purpose of this section has been to provide an overview of cognitive processes and the criteria they imply for evaluating educational software. It is hoped that as a result of this evaluative approach, readers will be able to better select software that will enhance student learning.

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APPENDIX B - PUBLISHERS LISTING

Aquarius
P.O. Box 128
Indian Rocks Beach, FL 33535

Avant Garde Creations
P.O. Box 30160
Eugene, OR 97403

Borns Software
19841 Sea Canyon Circle
Huntington Beach, CA 92648

Control Data Publishing - Plato
P.O. Box 261127
San Diego, CA 92126

Davidson and Associates
6069 Groveoak Place #12
Ranch Palos Verde, CA 90274

Deegan Learning Materials
P.O. Box 245
Mankato, MN 56001

Designware
185 Berry St., #3-158
San Francisco, CA 94107

Developmental Learning Materials
One DLM Park
Allen, TX 75002

Didatech
549-810 West Broadway
Vancouver, BC V524C9

Edu-Ware Service, Inc.
P.O. Box 22222
Agoura, CA 91301

Educational Activities
P.O. Box 392
Freeport, NY 11520

EduSoft
P.O. Box 2560
Berkeley, CA 94702

Gamco Industries
P.O. Box 310W23
Big Spring, TX 79721

Grolier Electronic Publishing, Inc.
95 Madison Ave.
New York, NY 10016

Hartley Courseware
123 Bridge Street
Box 419
Dimondale, MI 48821

Houghton Mifflin
One Beacon Street
Boston, MA 02108

Human Relations Media - HRM
175 Tompkins Ave.
Pleasantville, NY 10570

Learning Company
545 Middlefield Rd.
Menlo Park, CA 94125

Learning Well
200 South Service Rd.
Roslyn Heights, NY 11577

Math and Computer Education Project
Lawrence Hall of Science
University of California
Berkeley, CA 94720

Micro Ed
P.O. Box 444005
Eden Prairie, MN 55344

Micro Computer Workshops
103 Puritan Dr.
Port Chester, NY 10573

MicroMedia Publishing
6 Arrow Rd.
Ramsey, NJ 07446

Milliken Publishing Company
1100 Research Blvd.
P.O. Box 21579
St. Louis, MO 63132-0579

Milton Bradley Company
443 Shaker Rd.
East Longmeadow, MA 01028

Mindscape School Group
3444 Dundee Rd.
Northbrook, IL 60062

Minnesota Educational
Computing Consortium (MECC)
3490 Lexington Avenue
North St.Paul, MN 55112

Quality Educational Designs
P.O. Box 12486
Portland, OR 97212-0486

Random House
201 East 50th St.
New York, NY 10022

Recreational Mathematical Software
129 Carol Dr.
Clarks Summit, PA 18411

Renaissance Learning Systems
Tecumseh Building
Jamesville, NY 13078

Scholastic
730 Broadway
New York, NY 10031

Scholastic Software
P.O. Box 7502
2931 East McCarty Street
Jefferson City, MO 65102

Science Research Associated, Inc. (SRA)
55 North Wacker Drive
Chicago, IL 60606

Society for Visual Education, Inc.
1345 Diversey Parkway
Chicago, IL 60614

Southwest EdPsych Services
6342 W. Bell Rd.
Glendale, AZ 85308

Spinnaker Software
215 First St.
Cambridge, MA 02142

Springboard
7807 Creekbridge Circle
Minneapolis, MN 55435

Sterling Swift Publishing Company
7910 S. IH-35
Austin, TX 78744

Sunburst Communications
39 Washington St.
Pleasantville, NY 10570-9971

Teacher's Pet Software
1517 Holly St.
Berkeley, CA 94703

Terrapin, Incorporated
380 Green St.
Cambridge, MA 02139

The Learning Company
545 Middlefield Rd.
Menlo Park, CA 94025

Trillium Press
P.O. Box 921
Madison Square Station
New York, NY 10159

Unicom Software
297 Elmwood Ave.
Providence, RI 02907

Verbatim Corporation
4966 El Camino Real, Suite 228
Los Altos, CA 94022

Wadsworth Electronic Publishing
10 Davis Dr.
Belmont, CA 94002

Weekly Reader
1250 Fairwood Ave.
P.O. Box 16759
Columbus, OH 43216

XEROX Computer Software Division
245 Longhill Rd.
Middletown, CT 06457

APPENDIX C
SAMPLE SOFTWARE EVALUATION FORM

A Sample Software Evaluation Form

The following is a **sample software evaluation form** based on principles outlined in EVALUATING SOFTWARE FOR LEARNING OUTCOMES. No single evaluation form is best for every application. Use this software evaluation form only as a guide. Emphasize the questions that are most applicable to your teaching situation. Not all questions will apply to all teaching situations. Place less emphasis on what is less important in your classroom.

Software Title:

Publisher:

Price:

Required Hardware:

Description:

Verbal Knowledge

List the types of verbal knowledge that are intended to be taught by this software:

a)	f)
b)	g)
c)	h)
d)	i)
e)	j)

1=Strongly Disagree 2=Disagree 3=Agree 4=Strongly Agree

1 2 3 4	The software teaches the meaning of concepts as opposed to verbatim learning.
1 2 3 4	The software assesses prerequisite knowledge and skills.
1 2 3 4	The software teaches prerequisite knowledge and skills.
1 2 3 4	The software links new concepts to existing knowledge.
1 2 3 4	The software limits the amount of information presented on a single screen.
1 2 3 4	The software monitors student performance to provide selective repetition and feedback.

1 2 3 4 The software provides varied contexts for the encoding and retrieval of information.

Intellectual Skills

List the types of intellectual skills that are intended to be taught by this software:

a)
b)
c)
d)
e)
f)
g)
h)
i)
j)

1=Strongly Disagree 2=Disagree 3=Agree 4=Strongly Agree

1 2 3 4 The software pretests or teaches prerequisite verbal knowledge.

1 2 3 4 The software describes goals in detail.

1 2 3 4 The software describes the performance level to be achieved.

1 2 3 4 The software provides explicit cues to help students correctly sequence component skills.

1 2 3 4 The software requires students to provide concrete examples of a rule or procedure.

1 2 3 4 The software provides feedback to students, enabling them to check for understanding.

1 2 3 4 The software diagnoses student errors.

1 2 3 4 The software requires students to verbalize their understanding of knowledge or a skill.

1 2 3 4 The software teaches the whole concept or skill as opposed to separate component parts.

1 2 3 4 The software provides for student practice of the whole concept or skill.

1 2 3 4 The software provides varied contexts in which students are required to apply a rule.

Cognitive Strategies

List the types of cognitive strategies that are intended to be taught by this software:

a)	f)
b)	g)
c)	h)
d)	i)
e)	j)

1=Strongly Disagree 2=Disagree 3=Agree 4=Strongly Agree

1 2 3 4	The software pretests or teaches prerequisite verbal knowledge.
1 2 3 4	The software requires students to define a problem.
1 2 3 4	The software directs students toward a precise goal.
1 2 3 4	The software requires students to set sub-goals.
1 2 3 4	The software requires students to decompose a problem into a hierarchical form and solve from the bottom up.
1 2 3 4	The software provides a similar problem as a guide.
1 2 3 4	The instructional software emphasizes identifying contradictions.
1 2 3 4	The software provides a context for the problem.

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